AGRICULTURAL ENGINEERING

FEBRUARY • 1956

In this Issue . . .

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AGRICULTURAL ENGINEERING

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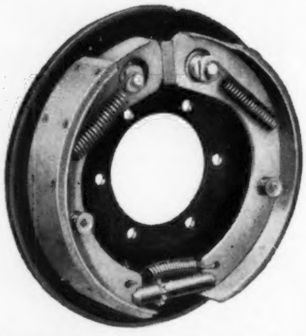

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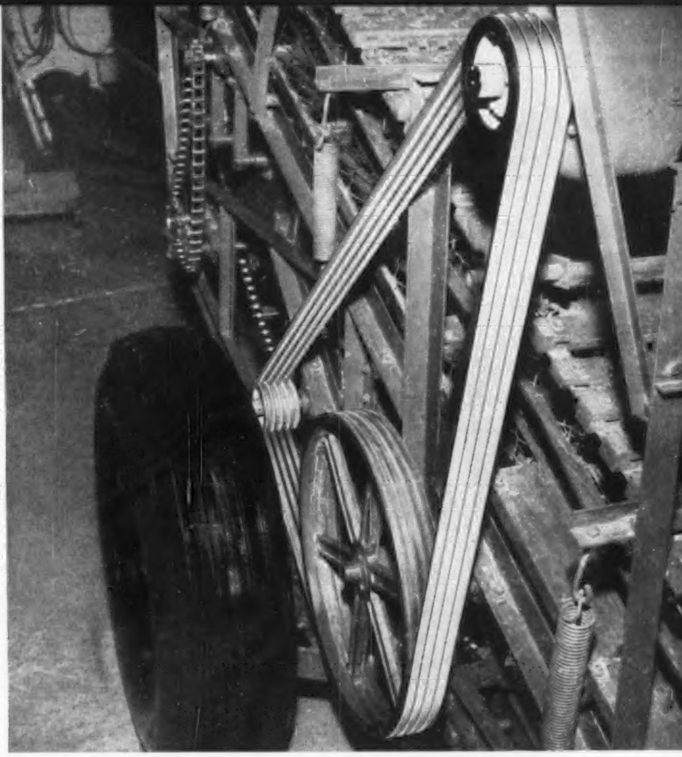

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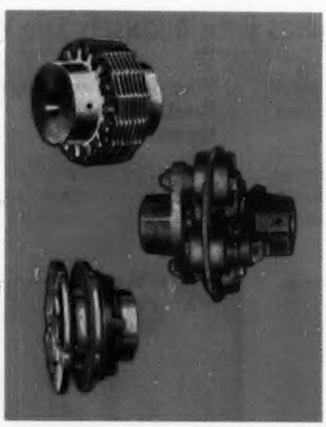

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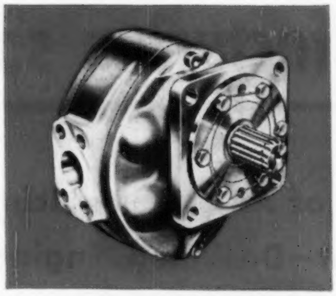

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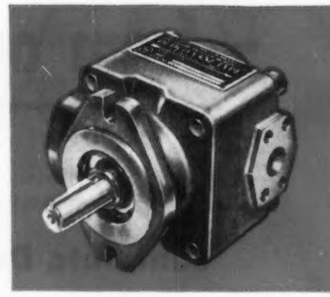

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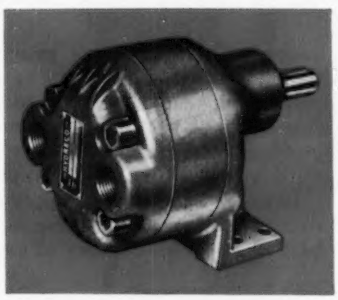

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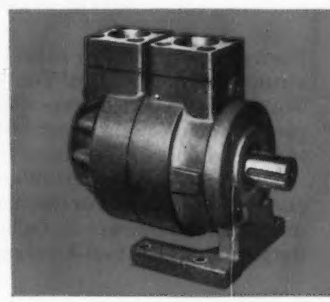

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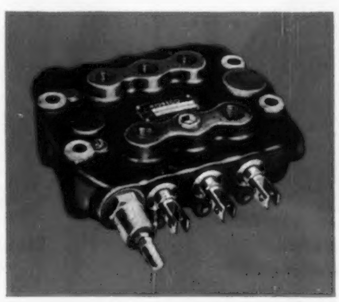

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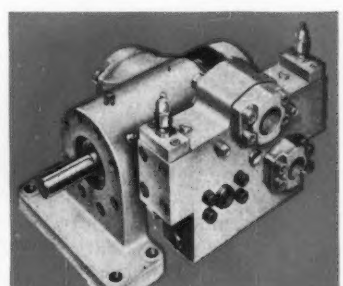

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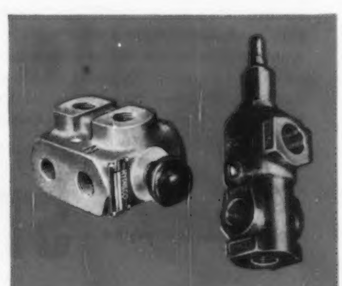

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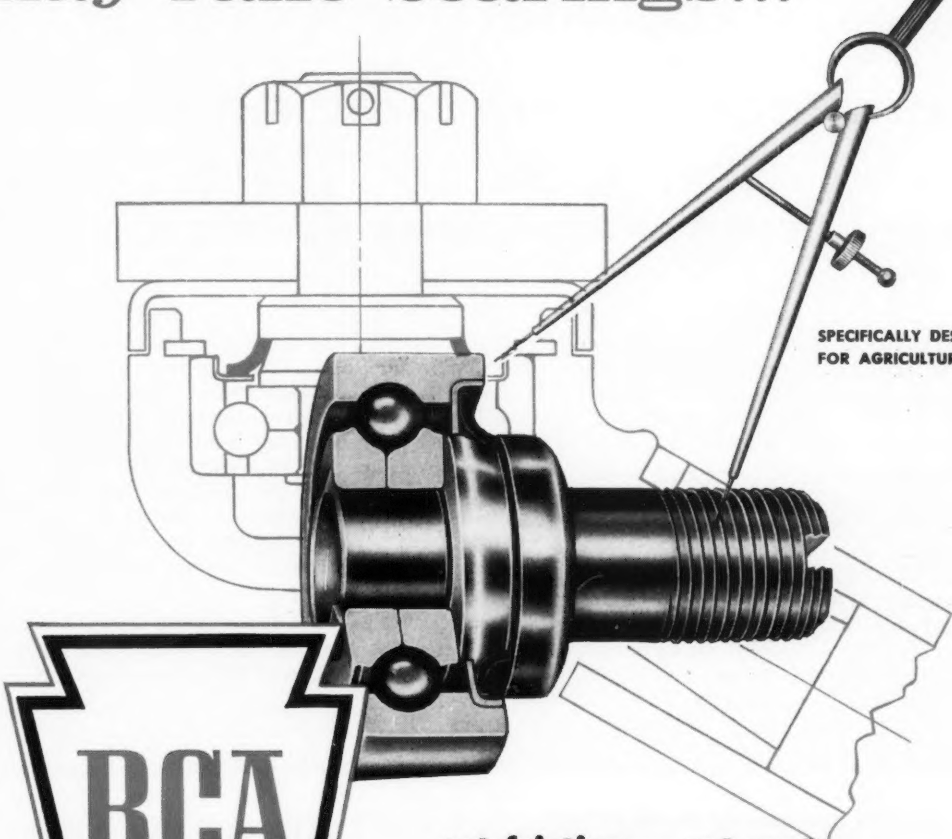

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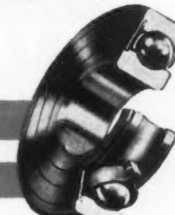

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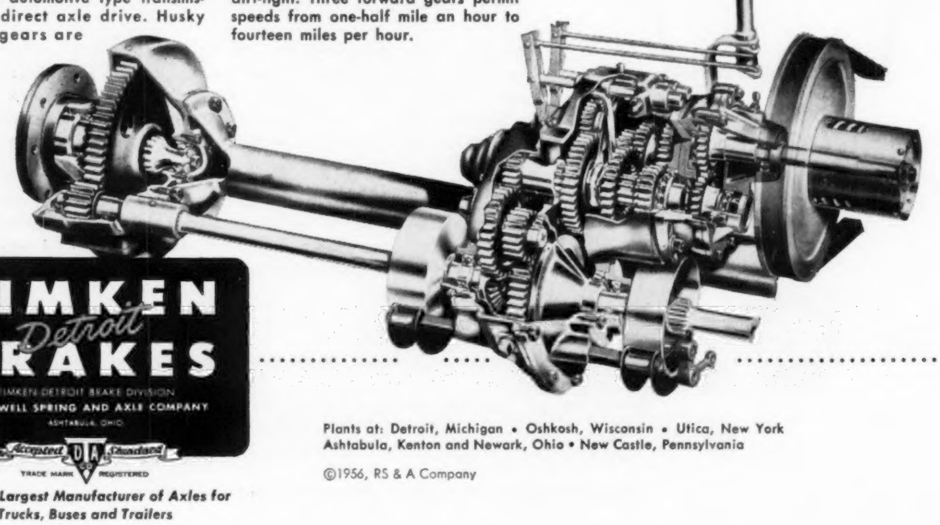

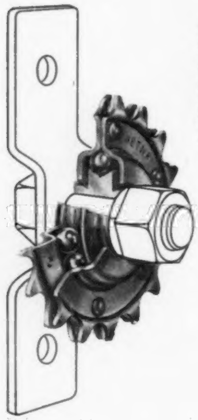

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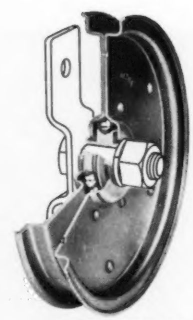

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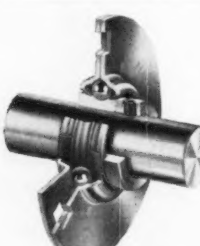

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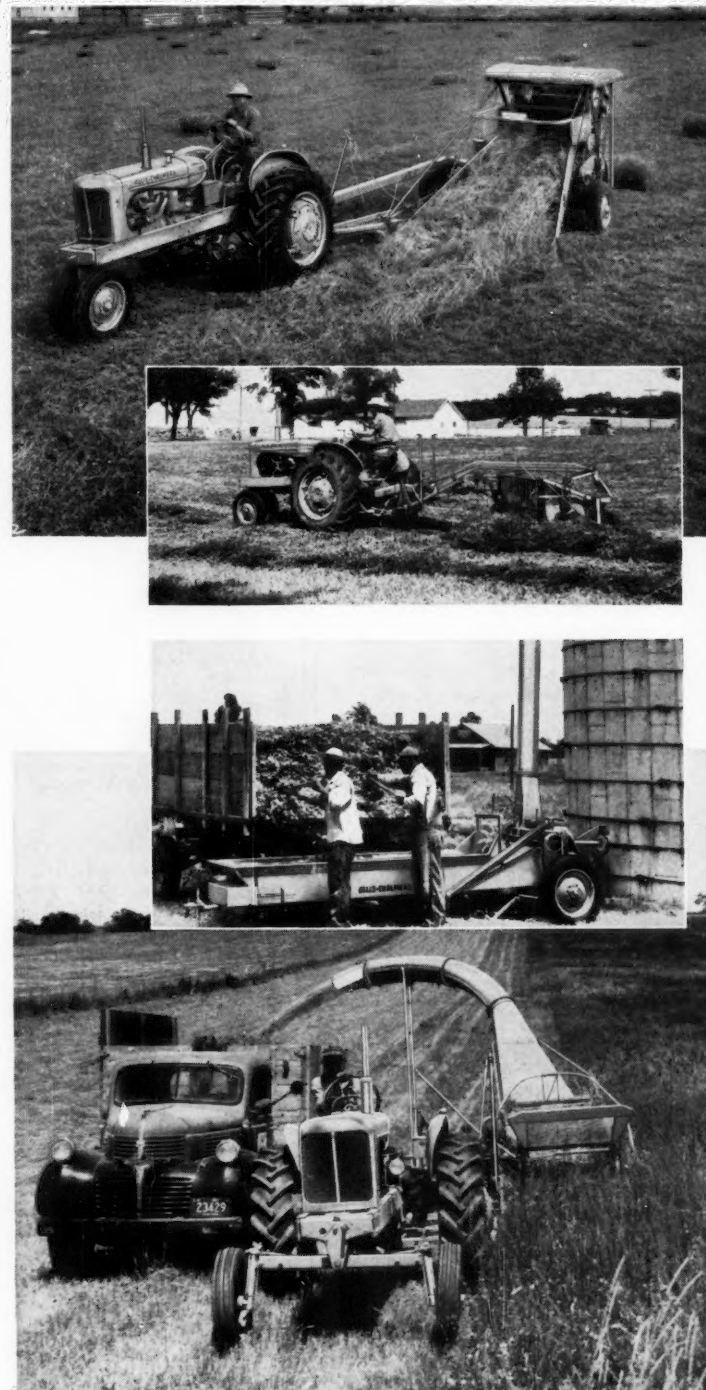

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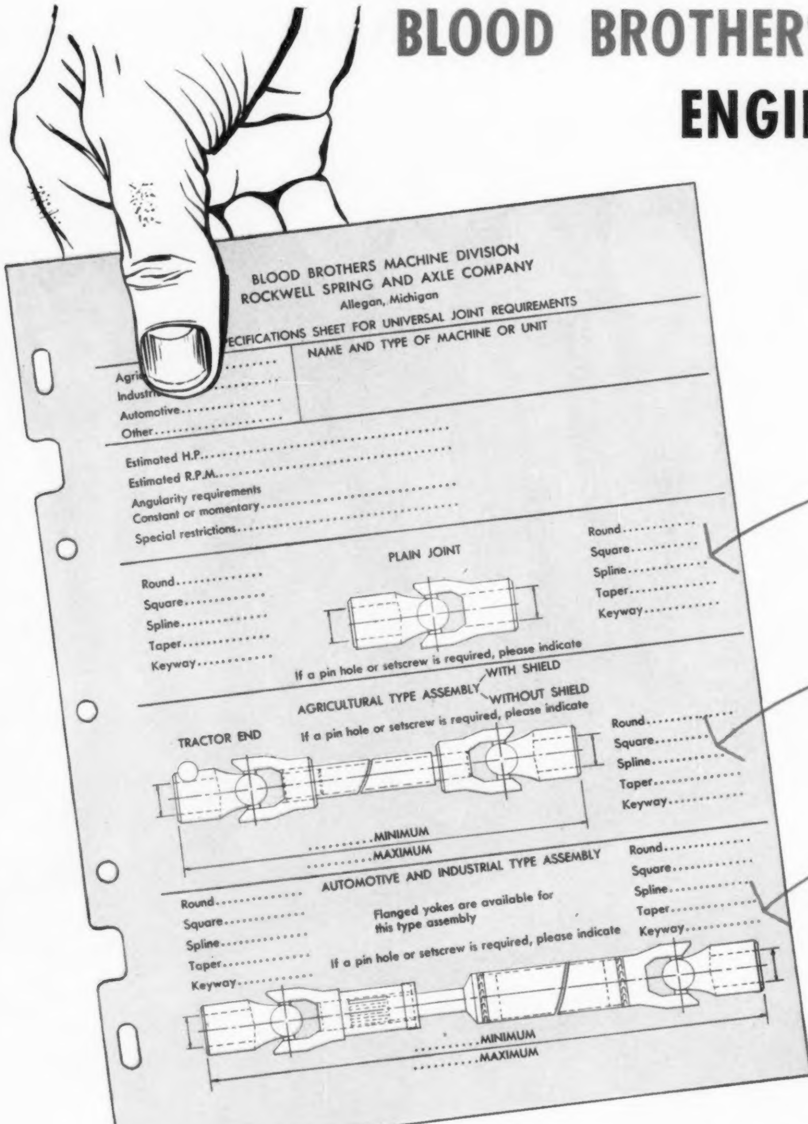

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AGRICULTURAL ENGINEERING

VOL. 37 FEBRUARY, 1956 No. 2

Corn Picker Features New Principle

C. B. Richey, J. F. O'Donnell, J. T. Ashton and R. J. Groves
Member ASAE Member ASAE

Application of a new principle in snapping the ear from the stalk reduces picking losses in new production corn pickers. Problems involved in development of the new pickers, as well as a description of mechanical features and some information on performance, are covered in this report

THE engineering features of a fully mounted one-row corn picker for a four-wheel tractor and of a two-row mounted model for a tricycle tractor are presented in this paper. These pickers have introduced a new principle in snapping the ear from the stalk, in that the stalk is bent sideways and passes through the snapping rolls at about a 45-deg angle. This action clears the ears from the rolls and reduces shelling losses.

Development of the new pickers came about primarily because of concern over high corn losses during picking. A research project was started by our company for the purpose of developing a simple light-weight picker that would have a higher harvesting efficiency than current pickers.

The first phase of the program involved a lightweight one-row mounted machine without a husking bed, but with a short husking section at the upper ends of the snapping rolls. The performance of this machine was comparable with current machines of the same type, but it was found impossible to reduce shelling losses. After trying many combinations of snapping-roll materials and configurations, serious shelling still occurred, primarily when a loose ear on the rolls was pushed into the rolls by an incoming stalk and ear. With this machine the ears were transported on up the rolls for husking. It seemed that there was usually a loose ear in the snapping area, and it would often be caught by the incoming corn and shelled before a chain finger could carry it away.

A possible remedy was to get the ears off the rolls as quickly as possible after snapping. Studies by W. H. Johnson of the Ohio Agricultural Experiment Station indicated significant differences in snap-roll shelling of individual ears by a conventional picker, depending on whether the ear hung on the side of the stalk toward the snapped corn elevator, where it could fall away from the rolls easily after being snapped, or whether it was on the side away from the elevator.

The simplest method of improving ear drop-off over conventional pickers appeared to be skewed rolls which would allow the stalks to enter at the bottom but bend them sideways at the snapping point. It seemed probable that normal stalk breakage problems would be greatly aggravated, but it was decided to rework a Wood Bros. pull-type picker for a tryout of the idea.

The rear bearing of the upper snapping roll was swung up about the lower roll bearing until a line through the roll bearings was about 15 deg from the vertical instead of 63 deg. This modification was made without benefit of drawings and first taken to the field in January. The first results were inconclusive because the stalks would not go back between the rolls, but pulled through at the lower end, ear and all. Modification and tryouts were continued as

Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1955, on a program arranged by the Power and Machinery Division.

The authors, C. B. RICHEY and J. F. O'DONNELL, are research engineers, research engineering section, and J. T. ASHTON and R. J. GROVES are harvesting engineers, harvesting engineering department, Tractor and Implement Division, Ford Motor Company.

Fig. 1 *(Left)* One-row mounted corn picker for the four-wheel tractor • Fig. 2 *(Right)* Two-row mounted corn picker for the tricycle tractor

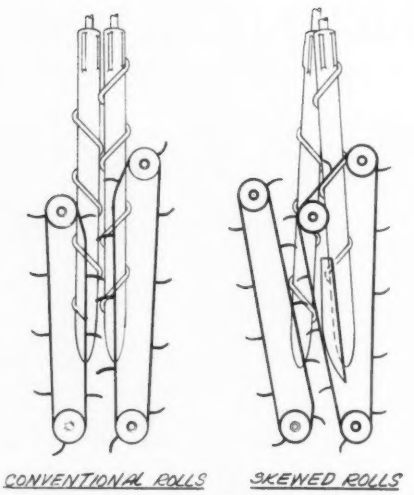

Fig. 3 Diagram showing arrangement of snapping rolls and gathering chains for both the conventional and side-snapping principle

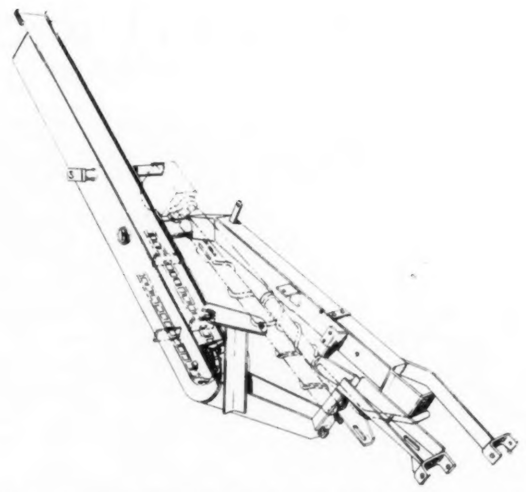

Fig. 4 Diagram of frame for new snapping unit using side-snapping principle

weather permitted. By the last of February we were able to get the stalks into the rolls and the ears snapped at the proper point. This was accomplished by angling the gathering-chain throat to help bend the stalks sideways and by shielding the lower end of the upper roll to close up the gap resulting from the skew of the rolls, and thus prevent ears from being pulled through.

A diagram of the arrangement is shown in Fig. 3. It appeared that the ears cleared the rolls much quicker than with the regular picker, and it also appeared that there was a reduction in shelling, although the corn had been wet by snow and did not shell easily. Shortly after this, the testing season was concluded. A completely new snapping unit was designed and built for the next fall testing. The following features were incorporated into this design in addition to the side-snapping principle:

- A short upper roll in combination with a stationary guide rod at the bottom
- Small-diameter rolls on 2½-in centers to reduce nipping of ears as much as possible
- A central gearbox for all drives including the snap-roll gears. This necessitated self-aligning couplings outside the gearbox to allow roll adjustment.
- A compact design which would be adaptable to a two-row mounted picker on a tricycle tractor as well as a one-row mounted picker on a four-wheel tractor. The side-snapping action tended to spread the rolls in a 45-deg plane instead of in a substantially horizontal plane as with a conventional picker, and it also required frame clearance for discharging the stalks to the side. These factors led to the use of the snapped-corn elevator return box as the major frame member. The snapping unit pivoted on arms attached to a tube passing through this box section and the frame arm for the upper roll was arched up for clearance and welded to a heavy tube passing through the box section. These tubes, of course, had to clear the returning chain conveyor. The general arrangement is shown in Fig. 4.
- A snapping unit that could be raised and lowered independently of the rest of the picker. To permit this, the drive to the snapping unit gear box passed through a double universal joint with one sliding hub, located with respect to the pivot so as to maintain approximately equal angles in the two joints throughout the operating range. This feature is shown in Fig. 7.

This snapping unit was mounted in a pull-type picker with a conventional husking bed, and used in Ohio and Michigan throughout that fall. Shelling losses were consistently lower than with other pickers operating in the same fields and no serious functional problems were encountered.

During the winter the snapping unit was incorporated into a one-row fully mounted design with husking bed. The snapping unit was carried outside of the right-hand rear wheel, as with the lightweight snapper tested previously. An analysis of the weight distribution indicated that the overhanging snapping unit would be best balanced if the tractor center line were as far as possible from the right-hand rear wheel and outboard-mounted snapping unit. Consequently the design provided for the right-hand rear wheel to be set 36 in from the tractor center line rather than 26 in, as with the original lightweight mounted machine. This outfit was operated and the handling characteristics were found to be reasonably good.

The snapping unit incorporating improvements found desirable in the previous fall's testing was used in combination with a production husking bed. Two of these one-row mounted pickers were operated, one in Ohio and Michigan and the other in the Des Moines area.

Little functional trouble was encountered in Ohio and Michigan, but the extremely dry conditions prevailing in

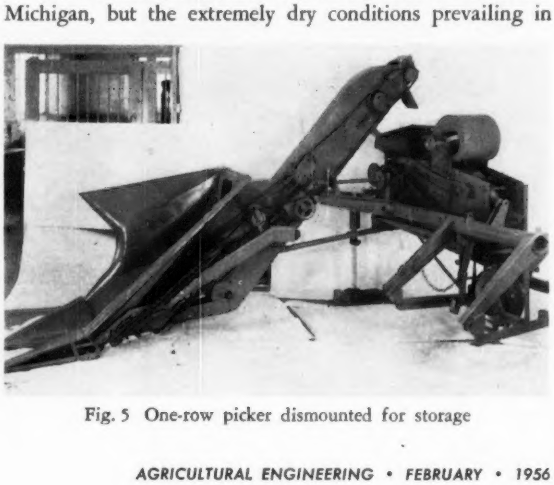

Fig. 5 One-row picker dismounted for storage

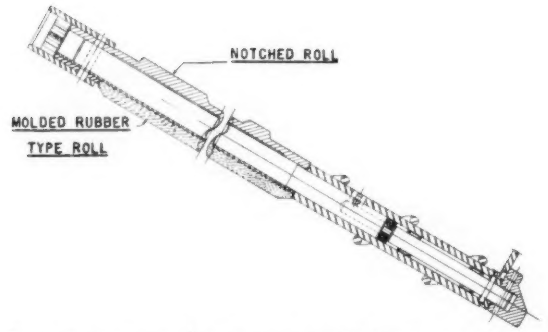

Fig. 6 Cross section of upper snapping roll showing lower bearing and interchangeable rubber sleeve

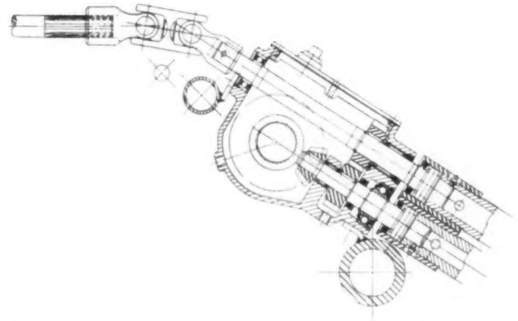
Fig. 7 Cross section of snapping roll couplings, gear box and universal joint drive

Iowa that fall provided a new problem. Light trash accumulated at the snapping rolls, eventually catching stalks and ears, causing clogging. A rubber sleeve on the upper roll helped greatly and did not seriously increase shelling losses in dry conditions. Some clogging still occurred, however, and a beater was installed above the elevator near the upper end of the snapping rolls to help force trash through the rolls or start it up the elevator. It proved to be effective.

In tall dry corn, ears tended to be thrown off as the stalks were bent sideways by the gathering chains. The right-hand flare sheet was built up to intercept the ears, but this resulted in a flare sheet too steep to allow down stalks to feed around properly. Too many down stalks were broken and the ears were lost. The final solution was a mitt-shaped flare sheet, shown in Fig. 2, that provided ear interception at the critical point, but also maintained a low rounded section for gentle feeding of down stalks.

The heavy production six-roll husking bed mounted across the back of the picker made it necessary to add front-wheel weights and axle weights for steering control. Late in the season a lightweight four-roll bed was tried. This bed had ribbed cast-iron rolls paired with rubber-fabric disk rolls driven by friction from the cast rolls. The rubber rolls were held against the cast rolls by spring pressure at both ends. In this way wear of the rubber was automatically taken up at either end. This bed was surprisingly effective for its size and weight and, because of its aggressiveness, it was not necessary for the ear forwarders to hold the ears down against the rolls. The bed was tried in snowy conditions and the friction drive continued to function, proving worthy of further consideration.

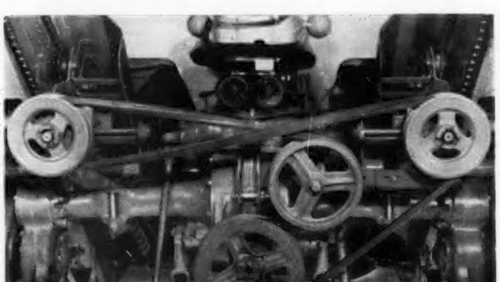
Fig. 8 Main V-belt drive on two-row picker

Testing of this model was concluded in December and the project personnel came in from the field and started on the next year's design. Redesign and improvement of the one-row mounted picker was carried on concurrently with the design of a two-row mounted picker for a tricycle tractor.

Longitudinal placement of husking beds would have resulted in excessive rear overhang of the tricycle tractor so it was decided to mount the beds crossways. The length of husking roll that could be used was dictated by over-all width limitations and the necessity for leaving adequate space in the middle for the hopper and ear corn elevator. In order to obtain every possible inch of effective husking roll length, conventional husking roll bearings were eliminated and stationary bearing spindles used in the ends of the rolls. These bearings proved to be durable and low in cost.

The one-row mounted pickers were tested in Michigan and Iowa and the first two-row picker was tested in Michigan. The latter had some mechanical deficiencies, but it functioned satisfactorily and did an acceptable job of husking in spite of the small beds.

Production of a fully mounted one-row picker for the four-wheel tractor and a two-row mounted model for a tricycle tractor was scheduled for the 1955 season.

New Mechanical Features

The production machines contain several departures from current corn picker design practice. Some of the more interesting are as follows:

Snapping Rolls. The construction of the lower bearing is shown in Fig. 6. The roll turns on a stationary spindle held loosely in a support plate so as to be self-aligning. The spindle is hardened and runs in a pair of needle bearings. Thrust is taken on the end of the spindle by a bronze plug that contains a passage to admit grease from a storage chamber above, which is recharged by grease gun once a day. The grease seal at the bottom of the roll, in combination with daily flushing, has been effective in keeping dirt out of the bearings.

A removable sleeve is used on the snapping section of the upper roll as shown in Fig. 6. A cast-iron sleeve with a conventional notched spiral flute is used in most conditions. It is coated with quartz particles, bonded to the metal with epoxy resin, in order to increase the coefficient of friction. This coating gives a better grip on smooth greenish stalks and also increases the ability of the cast roll to handle dry corn. The side-snapping principle allows the use of a rubber sleeve on the upper roll in dry conditions without excessive

shelling. The rubber sleeve snaps many ears clean and also reduces the amount of loose trash going up the elevator, thus easing the load on the husking bed, but it tends to slip in green or wet conditions.

The cast lower roll has a smooth rounded spiral. In green heavy stalks it was found necessary to add lugs held by capscrews to the lower roll. The lugs increased shelling surprisingly little.

Various cylindrical metal rolls have been tried, including quartz-coated. It has been concluded that, in many conditions, a rib of some type is required on a roll in order to take the node of a cornstalk through. Otherwise the stalk may stop when the node gets to the rolls and the spinning rolls will chew through the stalk, leading to clogging.

The snapping-roll drive coupling and gearbox is shown in Fig. 7. The upper end of the roll contains an internally splined hardened-steel sleeve which works in conjunction with a gear forged on the end of the gearbox shaft. This gear has its teeth rounded to allow approximately three degrees of angularity. These couplings must not only accommodate roll angularity but must also resist the spreading pressure on the rolls. This construction allows the roll to be slipped off and taken out when the lower spindle-bracket bolts are removed. By this means, upper roll sleeves can be easily changed in a few minutes. This arrangement also allows the roll drive gears to be enclosed in a gearbox with a pair of bevel gears that drive the other elements in the snapping unit.

Main Drive. V-belt drives are used on both pickers for reasons of quietness and simplicity. The one-row mounted is driven by a *C*-section V belt, 155 in long, running over a 13¾-in pitch diameter driving sheave on the power take-off and 9⅜-in pitch diameter driven sheave on the snapper drive shaft that drives the upper snapping roll directly through a double universal joint as shown in Fig. 5. The roller chain husking bed drive is taken off the rear of the snapper drive shaft.

The use of the same basic gearbox for both right-hand and left-hand snapping units was an important consideration in selecting a drive for the two-row mounted picker. This introduced the problem of driving the sides in opposite directions. The first experimental model used two independent V-belt drives from the pto. The belt to the left-hand unit was crossed to reverse the direction of rotation. The space on this side, however, did not permit a take-up idler without reducing the arc of contact of the driven sheave to an inadequate level. The single V-belt drive shown in Fig. 8 then was tried. The twists in this drive are within the recommendations of the "ASAE standard: V-Belt Drives for Farm Machines", and the fleeting angles are not excessive. Calculations indicated that the capacity of this drive should be adequate and they were validated by field experience. The *D* section V belt is of back-side-idler construction and is 181 in long. It runs over a 12-in pitch diameter driving sheave on the pto, 8.16-in pitch diameter driven sheaves and 10-in outside-diameter flat idler. The husking beds are driven by *B*-section V belts on the back ends of the snapping-unit drive shafts.

Husking Bed. A cross section through one of the friction-driven rubber rolls is shown in Fig. 9. The bearing setup is somewhat similar to the lower snapping-roll bearing

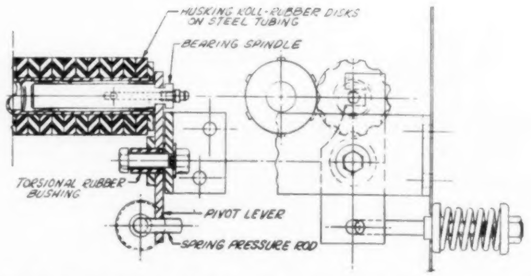

Fig. 9 Cross section of husking-roll bearing and spring-pressure arrangement

in that the stationary-bearing spindle is held loosely, allowing self-alignment. The spindle has milled flats on the end and these engage a slot in the upper end of a pivot lever which has a pressure spring acting at the bottom. A torsional rubber bearing is used at the pivot. Constant oscillation, resulting from the action of the cast ribs against the rubber rolls, caused rapid wear when unlubricated metal bearings were used. The bearing spindle is rifle-drilled and lubricated from the outer end so as to flush out dirt. The roll tube is reamed to accept bushings and sealed off with a welsh plug before the bushings are pressed into place. This setup is used at both ends of the rubber rolls and at the lower end of the cast rolls. The upper ends of the cast rolls are fitted with steel shafts which are carried in spherical outside-diameter sealed-for-life ball bearings held in a twin flange mounting.

Shelled corn losses over the husk conveyor were higher than desirable. More shelled corn was often brought up the elevator than with conventional pickers because the hopper pan extended under the snapping rolls and caught shelled corn that would otherwise be lost on the ground. This shelled corn dropped at the head of the husking rolls and there was only a short space available to sieve it out, particularly on the two-row picker. Louvres are used rather than round sieve holes, as shown in Fig. 10, in order to obtain quicker drop-out of kernels. The louvres provide more drop-out area and are less liable to clogging by small pieces of stalks than sieve holes.

Control of Gathering-Point Height. On both pickers the gathering-point height is controlled by the built-in

Fig. 10 Corn-saving louvres under husk conveyor

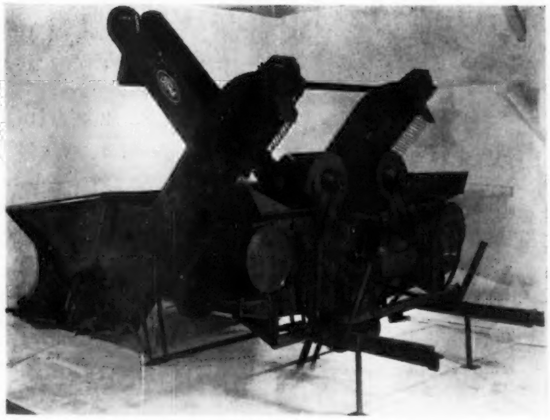

Fig. 11 Two-row picker dismounted for storage

tractor hydraulic system. One of the lift arms and rods is connected to a cross-shaft which in turn controls the gathering-point height by tilting the snapping unit. On the one-row model, the snapping unit is actuated by a compression link under the pivot, as shown in Fig. 5, while on the two-row model, a tension link above the pivot is used. The regular hydraulic control lever then provides control of gathering point height.

Attachment: On both the one-row and two-row models, the built-in tractor hydraulic system is used to lift the picker into position for attachment.

The one-row model is equipped with a leg under the elevator and a bumper jack at the right-hand end of the frame pipe, as shown in Fig. 5. When the lift shaft is locked, the snapping unit cannot pivot, and it serves as the third leg when the picker is dismounted. For mounting, the tractor is backed into place and the lower links and top link are attached to the picker. The hydraulic system and the bumper jack are used to lift the picker into position for inserting the mounting pins in brackets bolted under the tractor-axle housing.

The two-row model is assembled in two sections, snapping units and husking beds with elevator, as shown in Fig. 11. The husking bed is supported on three legs. For assembly, the tractor is backed into place and the links attached. The hydraulic system is then used to lift the assembly into place for attachment. After the lift arm has been connected to the picker-lift shaft, the tractor with husk beds is driven between the snapping units. The swing-down stands, located just behind the center of gravity of the snapping units, hold the mounting brackets high enough that the tractor axle can pass under. The tension connections from the picker-lift shaft are connected to the snapping units and the tractor hydraulic system is used to pull the picker mounting brackets down into place for attachment to the tractor axle housing. The snapping units rock back on their stands to allow this. The action is reversed for removal since the weight of the snapping unit, as it rocks forward on its stand, will lift the mounting brackets from the axle.

Power Requirements

Power requirements for the one-row picker were checked in wide-row corn grown with minimum tillage. This corn was planted in 56-in rows and yielded 107 bu per acre in the area where power checks were made. The row yield was the equivalent of 150-bu-per-acre corn in 40-in rows. Power was checked by strain gages on *(a)* the tractor pto, *(b)* snapping-unit drive shaft and *(c)* husking bed and elevator drive shaft. Checks were made in first gear and second gear on two different days, one dry and one damp. On October 28 and 31, the test dates, the ears contained about 22 percent moisture and many stalks were still slightly green. The results are shown in Table 1.

TABLE 1. POWER REQUIREMENTS FOR ONE-ROW CORN PICKER IN HEAVY CORN

	Number runs	Average snapping unit hp	Average husking bed and elevator hp	Average fan hp	Average total hp
No load	5	1.5	1.1	0.7	3.3
Dry conditions					
First gear, 1.9 mph	3	4.3	1.3	0.7	6.3
Second gear, 3 mph	3	5.0	1.6	0.7	7.3
Damp conditions					
First gear, 1.9 mph	4	6.2	1.4	0.7	8.3
Second gear, 3 mph	4	6.6	1.5	0.7	8.8
Snap Unit clogged	2	13.8	1.2	0.7	15.7

In spite of the increased volume of stalks, little additional power was required by the snapping unit when running in second gear rather than first. This was attributed to the greater help of the roots in pulling the stalks through at the lower ratio of roll peripheral speed to ground speed. Husking-bed power requirements varied little from no-load to full-load operation.

As shown in Table 1, the snapping-unit clogging load was approximately double the maximum operating load. The drive to the snapping unit did not slip in this case, but was probably close to the slipping load. The snapping unit is designed to withstand the maximum load that can be transmitted by the V belt and no protective slip clutch is used.

Power requirements for snapping corn vary greatly with conditions. Early picking in green corn requires much more power than after the stalks have been killed by frost and the ears snap more easily. Some tall heavy-stalked southern corn requires much more power than any in the corn belt.

Harvesting Efficiency

The harvesting efficiency of these pickers is bearing out the promise of the experimental models. In corn-picking contests, their shelled corn losses averaged one-half to three-fourths the shelled corn losses of conventional pickers. This advantage increases as the corn becomes drier and shelling losses increase. Shelling losses with these pickers also are less affected by roll adjustment than with conventional pickers. In easily shelled heavy corn where the conventional rolls become heavily loaded with a mass of trash and ears, the advantage in low shelling is sometimes as high as ten to one.

The side-snapping principle has not increased ear losses. These pickers held their own in picking up down stalks and saving ears in picking contests. Husking was on a par with other pickers, although the severe husking rolls plus more shelled corn saved from the snapping unit resulted in more shelled corn in the wagon, in some cases.

Hot Weather Shelters for Dairy Cows

G. L. Nelson, E. R. Berousek and Geo. W. A. Mahoney
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Proper design, often without an appreciable increase in cost, can provide worth-while reduction in heat gain to a cooled dairy shelter. Such things as proper placing of natural ventilation openings and orientation of shelter in respect to prevailing winds are important factors in keeping cows cool in summer. Temperatures, relative humidities and moisture vaporization within different types of shelters, using various types of cooling methods, are reported

THE lower central and southwestern regions of the United States experience much uncomfortably hot weather each summer. As measured by total hours per season with dry-bulb temperatures above a specified level, the hottest extensive area in the country extends through central Texas and Oklahoma. If dairy production under dairy farm conditions could be improved by cool shelters, such shelter obviously would be of economic importance. These considerations led to an experiment at Stillwater with summertime shelters for lactating dairy cattle which began in the late summer of 1950 and extended through the summer of 1953.

Description of Experiments

The experiments were designed to obtain data that would indicate wherein comfort conditions for dairy cattle during hot summer weather could be improved by low-heat-gain shelter construction in combination with special cooling and ventilating equipment, also to obtain data on the effectiveness of cool shelter in improving dairy cattle performance under good dairy farm management practices, as compared to uncontrolled shelter and complete absence of shelter.

Two special shelters were constructed for the experiments. One shelter was a completely enclosed and insulated masonry structure 26 ft wide by 50 ft long. The other shelter was a relatively simple open-front, south-facing structure 26 ft, 6 in wide, by 48 ft, 8 in long. Additional details have been given in another paper (1)*. The masonry shelter was equipped with an 8,000-cfm evaporative cooler and two 30-in attic fans for temperature control and ventilation.

The experiments that have been conducted on performance of the shelters include studies of heat gain through concrete block masonry, operational costs and effectiveness of the cooling and ventilating equipment, attic space ventilation, wind ventilation in the open-front shelter, and surface temperatures of metal building coverings. Some of the results of experiments on heat gain through masonry walls and temperatures of building coverings have been reported previously (1, 2, 3). Experiments with lactating dairy cattle were conducted to obtain measurements of their response to summertime shelter under good dairy farm management. Studies have been made on feed and water consumption, shelter occupancy, surface and body temperatures, respiration rates, and milk production.

Cooled Shelter Performance—Temperatures

The insulated shelter was cooled by an 8,000-cfm evaporative cooler. Cooler operation was controlled by a standard bimetallic switch which operated on a 5-deg temperature variation and was normally set to turn the cooler on at 80 F. The cooling effect obtainable with evaporative coolers depends upon the wet-bulb temperature of the air. A well-designed cooler in good condition will give dry-bulb temperatures at the cooler outlet within a few degrees of the wet-bulb temperature.

A continuous trace of temperatures in the cool shelter was maintained with a recording hygrothermograph mounted near the center of the shelter and 3 ft above the floor. During the summer of 1950, an analysis of the daytime temperatures on seven of the hottest days indicated that the average difference between maximum indoor and outdoor temperatures was approximately 12 deg. This was an unusually cool summer, with a maximum temperature during the experimental period of 97 F. During the 1951 experimental period, the maximum daytime temperatures in the cool barn averaged 84 F with an average maximum outdoor temperature of 92.5 F. A regression study of the outdoor, t_o and indoor, t_i, dry bulb temperatures during the 1952 summer for temperatures at 4:00 p.m., normally the time at which peak temperatures occur, gave the regression expression $t_i = 0.298\ t_o + 56.5$ deg. For example, at an outdoor temperature of 105 F, the indoor temperature would be approximately 88 F, and at an outdoor temperature of 95 F, the indoor temperature would be approximately 85 F.

A similar analysis was made for the 1953 summer, which yielded the regression $t_i = 0.227\ t_o + 61.6$ deg. During both the 1952 and 1953 summers, the shelter was occupied by four lactating dairy cows, including an Ayrshire, Guernsey, Jersey, and Holstein. During both summers, the cattle were penned in the shelter after the morning milking and held until approximately 4:00 p.m., at which time they were taken out for milking.

Cooled Shelter—Relative Humidity

A characteristic of evaporative cooling is that the moisture ratio and hence the relative humidity of the air in the cooled space is increased. Experiments (4) with Holstein and Jersey cattle have shown that at temperatures above 85 F, more than 70 percent of the total heat production may be dissipated in the form of vaporized moisture. Therefore, it is likely that high relative humidites would make heat dissipation by dairy cows more difficult. The relative humidity in the cool shelter during the 1952 and 1953 summers generally fluctuated between 70 and 80 percent during the afternoon hours when temperatures were highest, and seldom exceeded to 80 percent. Mean relative humidity at 4:00 p.m. during the 1952 summer averaged 72 percent.

Revised paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1954, on a program arranged by the Farm Structures Division.

The authors—G. L. Nelson, E. R. Berousek and Geo. W. A. Mahoney—are, respectively, professor of agricultural engineering, assistant professor of dairying and assistant professor of agricultural engineering, agricultural experiment station, Oklahoma A. and M. College, Stillwater.

*Numbers in parentheses refer to the appended references.

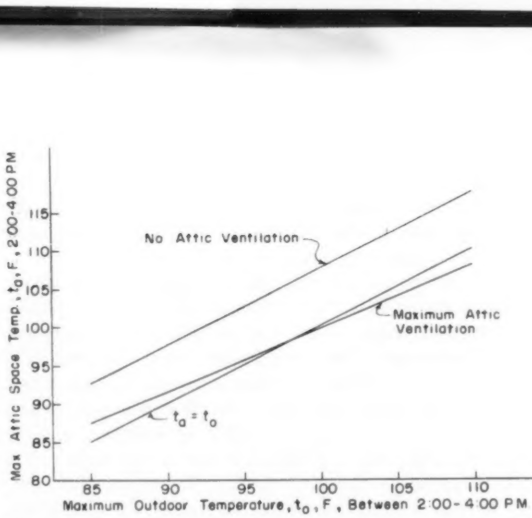


Fig. 1 Dry-bulb temperatures in attic space over an evaporatively cooled dairy cattle shelter

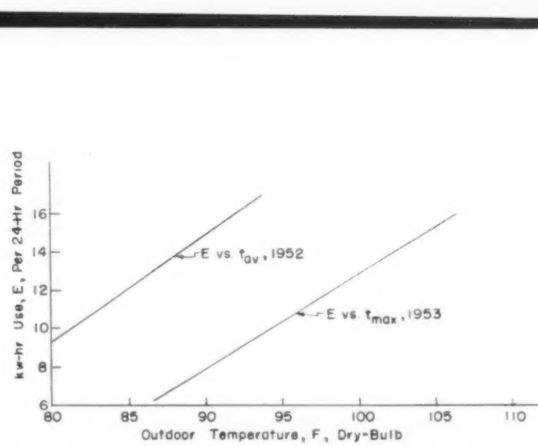


Fig. 2 Power requirements for evaporative cooling of a dairy cattle shelter

Cooled Shelter—Attic Space Temperatures

It is common knowledge that enclosed attic spaces may experience high temperatures during hot summer weather. When the space below is to be cooled, high attic temperatures can result in appreciable heat gain to the space below. If attic space temperatures can be kept near outdoor temperatures by generous ventilation of the attic space, a worthwhile reduction in heat gain could be obtained. An experiment on the effect of varying amounts of gable end attic ventilation was conducted during the summer of 1952. The attic space was ventilated by a screened and louvered opening in the east gable end with a net free opening of 11½ sq ft, and an access door in the west gable end with an opening area of approximately 7½ sq ft. A special set of shutters was provided for the louvered opening so that it could be closed completely, opened one-third, opened two-thirds, or fully opened. A continuous trace of temperatures was maintained with a recording thermometer with the sensing element suspended midway between roof and attic floor about 15 ft from the east gable. All of the attic temperatures under the various ventilation treatments were lower than had been anticipated. Linear regressions of maximum attic temperature between 2:00 to 4:00 p.m. on maximum outdoor temperature are shown in Fig. 1 for the two extremes of ventilation, namely, no gable-end ventilation and ventilation with all available openings in the gable ends, or a total net free opening of 19 sq ft, or approximately 1.4 percent of the attic floor area. As is apparent from inspection of Fig. 1 generous ventilation of the attic space results in a worthwhile reduction in attic temperatures. For example, at an outdoor temperature of 100 F, the temperature differential between attic space and cooled space below would be approximately 21 deg with an unventilated attic, and approximately 14 deg with a well-ventilated attic. Thus, under these conditions, a reduction of one-third in heat gain to the cooled space was achieved by increased ventilation. This would be equivalent to adding a 1-in insulation blanket to a ceiling consisting of ⅜-in gypsum lath with a 1-in insulation blanket, according to over-all conductance coefficients published in the American Society of Heating and Ventilating Engineers 1950 Guide. It will be noted from Fig. 1 that above outdoor temperatures of close to 98 F, the attic space temperature was below outdoor temperature. This was no doubt due to the cooling effect on the attic of the cooled space below.

Cooled Shelter—Use of Ventilating and Cooling Equipment

The shelter was equipped with two 30-in attic fans which exhausted air from the shelter space into the attic through two hatches in the ceiling. In central Oklahoma, nighttime temperatures at 4:00 to 6:00 a.m. during hot summer weather generally fall 20 to 25 deg below maximum daytime temperatures. Some advantage might be taken of this condition to obtain cooling effect in a temperature-controlled shelter by ventilation with attic fans during the cool hours of early morning. This cooling effect might then be evidenced in the form of reduced operational requirements for the evaporative cooler the following day. An experiment during the 1952 summer was conducted to test this hypothesis. Two ventilation treatments were assigned at random to either of two 5-day periods within a 10-day period, with a total of five 10-day periods. Treatment 1 provided for no operation of attic fans, with ceiling hatches closed. Treatment 2 provided for operation of both fans during the period 4:00 to 6:00 a.m. The ceiling hatches to the attic fans were opened at 4:30 or 5:00 p.m. the previous evening. Mean power consumption per 24-hr period by the evaporative cooler was 10.2 kw-hr when no nighttime attic fan ventilation was employed, and 9.7 kw-hr when two attic fans were operated from 4:00 to 6:00 a.m. Analysis of variance of the evaporative cooler power consumption data as affected by fan operation yielded an f value non- significant at the 5 percent level. Presumably no significant cooling effect was obtained by the attic fan ventilation since the structure would have already been cooled to 80 F or below by evaporative cooling.

The power requirements for evaporative cooling of the structure as a function of dry-bulb temperature are presented in Fig. 2. The linear regression expression $E=0.56\ t_{avg}—35.48$ was fitted by least squares to the 1952 data, where t_{avg} is the average of the daily maximum and minimum temperatures. The regression line representing $E=0.50\ t_{max}—36.79$ was fitted to the 1953 data, where t_{max} is the daily maximum temperature. Over-all mean power consumption by the evaporative cooler for the 1953 summer was 8.6 kw-hr per 24-hr period and, for the 1952 summer, 10.1 kw-hr per 24-hr period. Relatively cool weather prevailed during the latter part of July and August in 1953.

Open Shelter

Comfort conditions within an open livestock shelter will depend on numerous factors included in weather and structural environment. In a relatively dry climate such as is

characteristic of central Oklahoma, the dry-bulb temperature and wind velocity existing in an open shelter with a relatively high roof will be among the important indices of comfort conditions in an uncontrolled shelter. Experiments were conducted on these factors in the open shelter used in this study.

Open Shelter—Temperature Variations

An analysis to compare maximum temperatures in the shelter with maximum outdoor temperatures for a 48-day period during the 1952 summer was made. It indicated that temperatures in the open-front shelter were from ½ to 1½ deg higher than outdoor temperatures. These differences were statistically significant at the 1-percent level. The temperature measurements were all made with all rear wall openings closed. It is reasonable to suppose that ventilation openings in the rear wall to permit increased air motion through the shelter would result in shelter temperatures closer to outdoor temperatures.

Open Shelter—Wind Effects

Cattlemen are generally of the opinion that cattle are more comfortable if summertime shelters are equipped with generous openings to permit increased air motion. Two series of measurements of air motion through the south-facing, open-front shelter as a function of outdoor wind and amount of opening in the rear wall were made in 1950 and 1952, respectively. The 1950 experiments have been described in another paper (1). These 1950 experiments yielded data on air motion at two levels with varying amounts of opening in the lower half of the rear or north wall. The 1952 tests were conducted in similar fashion, but with openings in the upper half of the north wall. Fig. 3 shows the combined results for the 1950 and 1952 tests. It appears that air motion in the front portion of the shelter is about the same, regardless of whether the upper or lower half of the wall is opened up. As would be expected, air motion appears to be radically affected at the rear of the shelter, depending upon whether the openings are high or low in the wall. With openings in the lower half of the rear wall, air is evidently funneled downward near the rear of the shelter, so that a pronounced draft is obtained at the 30-in level. At the 5-ft level, at the rear, air motion appears to be but little affected by outdoor wind velocity when the openings are in the lower portion of the wall only. Here, "rear" refers to a line 6 ft from the north wall of the shelter, and "front" refers to a line 6 ft from the open front.

Effect of Air Motion on Surface Cooling of Cattle

It is well known that the surface coefficient for forced convection heat transfer increases with rate of air motion across the surface. For surfaces exposed to strong solar irradiation, it has been demonstrated (5) that increased air motion over the surface can have an important effect in reducing surface temperatures. Numerous temperature measurements were made on surfaces of cattle in the shelters at various air speeds. The temperatures were observed with a prong-type, 20-gauge, iron-constantan thermocouple holder. Observations were made on three relatively closely spaced spots on each cow. The cattle included a Guernsey, Jersey, Ayrshire, and a Holstein in the cooled shelter, and a similar group in the open shelter. Temperature observations were conducted during the summer of 1953 on a total of six days at 10-day intervals. Air motion was measured with a rotating-vane anemometer held at the location of the cow whose surface temperatures were being observed.

A linear regression analysis of the average surface temperatures of the four cows in each shelter on ambient dry-bulb temperature indicated that the skin-to-air temperature gradient became zero at 96 F. These data were selected for low wind speeds with a mean speed of 85 fpm, a maximum of 383 fpm, and a minimum of 0 fpm. The regression obtained was $(t_s-t_a)=91.35-0.95\ t_a$, where t_s is the skin-surface temperature and t_a is ambient air temperature, all in degrees Fahrenheit. Five sets of temperature observations made in the blast from the evaporative cooler on each of the four cows gave a mean skin-to-air temperature gradient of 13.4 F at a mean air velocity of 775 fpm and a mean ambient air temperature of 79.3 F.

The effect of air motion in increasing the cattle hair surface film coefficient of heat transfer can be evaluated by means of the ratio $(t_s-t_h)/(t_h-t_a)$. If a heat transfer balance is written across the hair coat and the hair-to-air film under conditions of negligible irradiation, and the resulting expression is rearranged, we obtain

$$f_h/c=(t_s-t_h)/(t_h-t_a) \quad . \quad . \quad . \quad . \quad . \quad [1]$$

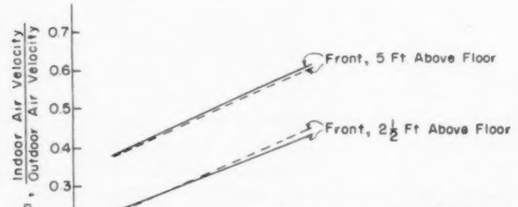
where c = hair-coat conductance, Btu per hr per sq ft per degree F

f_h = film coefficient of heat transfer for hair surface Btu per hr per sq ft per degree F

t_s = skin-surface temperature, degrees F

t_h = hair-surface temperature, degrees F

t_a = ambient air temperature, degrees F.



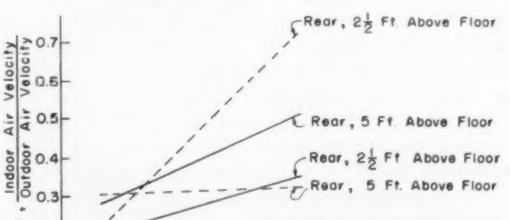


Fig. 3a *(Left)* and Fig. 3b *(Right)* Effect of rear wall openings on air motion through an open-front cattle shelter. "Front in Fig. 3(a) refers to a line 6 ft from the open front. "Rear" in Fig. 3(b) refers to a line 6 ft from the north wall of the shelter

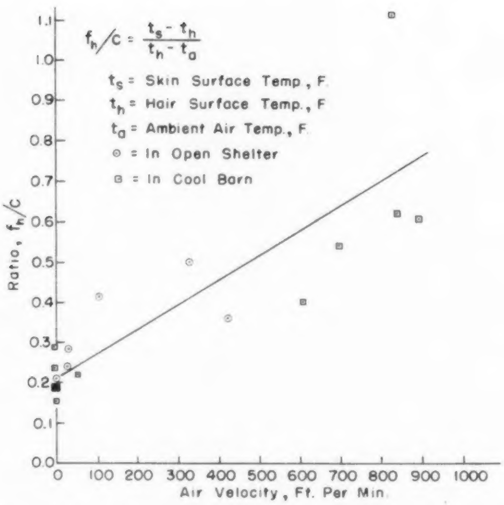


Fig. 4 Effect of air motion on temperature gradient at surfaces of dairy cattle

The temperature ratio $(t_s - t_h)/(t_h - t_a) = f_h/c$ was computed for temperature observations on cattle in both shelters. Fig. 4 is the straight-line regression of f_h/c on air speed, which regression is represented by $f_h/c = 5.565 \times 10^{-4} V + 0.209$, where V is ambient air speed in feet per minute, and the constant 5.565×10^{-4} has the dimensions of minutes per feet. Each point in Fig. 4 represents the average of a set of 15 observations on four cows. Three observations in each set were made on a Jersey, Ayrshire, and a Guernsey cow, respectively; and three each on black and white areas on a Holstein cow. Observational periods were at 10-day intervals during the 1953 summer.

Air speed was measured for each set of temperature observations by a hand-held, rotating-vane anemometer. Statistical test for zero slope of the regression line gave a t_b value of 4.687, significant above the 1-percent level. Therefore, if the hair-coat conductance c is practically constant for different wind speeds, it appears that air motion has an important effect on the film coefficient of heat transfer for cattle hair surfaces.

An increase in the value of the film coefficient will result in increased surface cooling. This effect is evaluated in Fig. 5 as a ratio of the convective cooling at wind speeds from 0 to 1,000 fpm to convective cooling in still air. The ratios plotted in Fig. 5 were computed by combining the foregoing regression equation for f_h/c assuming t_s varies only with t_a, with the expression

$$(q_c/A)_w/(q_c/A)_{st} = \frac{(f_h/c)_w}{(f_h/c)_{st}}\left[\frac{(f_h/c)_{st}+1}{(f_h/c)_w+1}\right] \quad [2]$$

To give

$$(q_c/A)_w/(q_c/A)_{st} = \frac{2.663 \times 10^{-3} V + 1}{4.603 \times 10^{-4} V + 1} \quad [3]$$

where q_c/A is the surface cooling effect due to convective cooling, Btu per square foot per hour, and the subscripts w and st refer to conditions of wind and still air, respectively. From Fig. 5 it is evident that a wind speed of 10 mph (880 fpm), for example could more than double the surface convective cooling rate from surfaces exposed to wind.

The foregoing analysis presumes that the ambient temperature is below the animal surface temperature; otherwise, convective heat transfer will be zero or will cause surface heating. At ambient air temperatures above the animal surface temperature, increased air speed obviously will cause increased heat gain to the surface. However, the increased convective heat gain could be partially offset by increased evaporative cooling. Thompson and others (4) have measured the rate of moisture evaporation from dairy cattle under laboratory conditions for air temperatures up to 105 F, and have determined that at high ambient air temperatures, evaporative cooling from the skin surface is an important mode of heat dissipation. Spielman and Jakob (6) have measured evaporation from surfaces of porous alundum plates kept moist and subjected to a flat air jet at relatively high velocities. They obtained correlations between a modified Nusselt's number, in which the coefficient of vapor transfer from surface to air appears, and Reynolds' number for the air stream. Their correlations show that the time rate of vapor transfer from the surface to the air stream varies directly as the 0.8 power of the surface air speed, as well as other factors including kinematic viscosity of the air, mechanical diffusivity of the surface film, vapor pressures of the surface moisture and vapor in the air, respectively, and the average absolute temperature of the surface and the air stream.

It is evident that air motion has an important effect in increasing moisture vaporization from a cow's surface, and thereby increases the evaporative cooling effect, even though air temperatures may be higher than the animal-surface temperatures. This cooling effect would of course be limited by the amount of moisture which the cow can supply at its surface. When the cow's surface is cooler than the air, evaporative cooling effect will be further modified by heat transferred to the cow's surface from the warmer air. Not all of the heat of vaporization of the moisture will serve to dissipate heat from the cow's surface, since some of the heat needed to vaporize the moisture will be transferred from the air to the cooler surface on which vaporization is occurring. For instance, with an air-to-hair temperature gradient of 4 F, and a still-air-surface heat-transfer coefficient of 3.5 cal per sq m per hr per deg F, the heat from the air to the cow's surface would be 14.0 cal per sq m per hr. Thompson (7) determined that the hair-to-air surface film

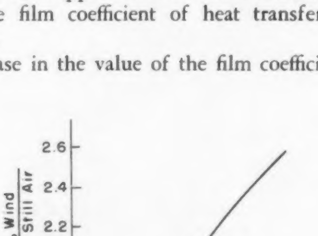


Fig. 5 Effect of wind speed on convective cooling of dairy cattle surfaces

co-efficient was relatively constant at between 3 and 4 cal per sq m per hr per deg F.

Performance of Lactating Dairy Cattle

The major objective of the experiments from the dairy production standpoint was to determine whether milk production and other dairy cow performance factors were influenced by the type of hot weather shelter available to lactating dairy cattle. The shelters used in these experiments included the evaporatively cooled, masonry shelter, and the open-front shelters previously mentioned and described. During the 1952 and 1953 summers, the effects of absence of all shade and shelter were also studied.

During the first and second summers, 10- and 20-day double reversal cycles, respectively, were used with two 10-cow groups in which each cow in one group was matched with a cow in the other group. After the first summer, all shade trees in the pastures were fenced to prevent access by the cows. During the third and fourth summers, the design of the experiment was changed to provide three randomly selected 4-cow matched groups, with one cow each of the Ayrshire, Guernsey, Holstein, and Jersey breeds in each group. The group using the cooled shelter was confined to the shelter between morning and evening milkings, but allowed free access to the pasture and shelter during nighttime. The group using the open shelter had free access at all times to the shelter and the pasture. The third group was confined day and night to a pasture with no shade or shelter. The three pastures used by the three groups were of comparable size and grazing quality. Each group remained in its respective pasture and shelter throughout the summer during the last two summers.

The milk production data for each of the four summers were subjected to statistical analysis. None of the data yielded a statistically significant difference in milk production as affected by type of shelter.

During the fourth year, certain physiological factors were measured. Some of these factors indicated that the cattle in the unsheltered group were under some degree of stress due to heat. Differences in body temperature were statistically significant, with the group in the open shelter exhibiting the lowest body temperatures. The afternoon respiration rates and pulse rates were lowest for the group in the open shelter and highest for the group with no shelter. Water consumption during the 1952 summer averaged 58.4 gal per 24-hr day per group of four cows for the group sheltered in the cool barn, 77.4 gal per day for the group in the open shelter, and 76.8 gal per day for the group with no shelter. For the 1953 summer, the comparable water consumption data were 58.9 gal per day for the group in the cool barn, 54.5 gal per day for the group in the open shelter, and 73.0 gal per day for the group with no shelter.

Each of the three groups was fed hay and silage *ad libitum* in bunks in its respective pasture or shelter. Daily silage consumption in 1953, per group, was 102.3 lb for the group in the cool shelter, 93.6 lb for the group in the open shelter, and 96.0 lb for the unsheltered group. Daily hay consumption for the corresponding groups was 44.0 lb, 38.5 lb, 45.7 lb, respectively. The higher consumption by the group in the cool shelter was no doubt partially due to the fact that the cows were able to graze only at night, whereas the cows in the other two groups were free to graze day and night.

On the basis of the dairy cattle performance data collected during the four summers, it seems clear that under hot weather environmental conditions which include low daytime humidity, dependable breezes both day and night, and relatively cool nights, an insulated, evaporatively cooled shelter offers no particular advantage as a shelter for lactating dairy cattle, either from a management or production standpoint, provided that the cattle are properly managed and maintained at a desirable level of nutrition. Doubtless one of the environmental factors that was important to the results from these experiments was the comparatively high relative humidity maintained in the evaporatively cooled shelter. It is apparent that evaporative cooling from a cow's surface will decrease with increased relative humidity. However, humidity control is not possible with evaporative cooling, and temperature control is limited by outdoor wet-bulb temperature. It is reasonable to suppose that in a summertime shelter equipped with refrigerative cooling equipment which would permit positive control over dry-bulb temperature and humidity, desirable effects might be obtained on milk production and other performance factors. However, the higher initial cost and daily operating costs of refrigerative cooling equipment would be a most important economic factor.

Conclusions

It appears feasible from an engineering standpoint that, under Oklahoma conditions, a reasonably well-insulated dairy cattle shelter can be cooled with an evaporative cooler that will circulate at least 0.7 air change through the structure per minute. Average power requirements will be slightly over 1 kw-hr per 24-hr period per 1000 cu ft of cooled space in the shelter. If the cooler is maintained in good operating condition, dry-bulb temperatures below 85 F can be maintained during the hottest hours of the day when outdoor temperatures are as high as 100 to 105 F. Relative humidity in the shelter will fluctuate between 70 and 80 percent during the afternoon hours. These relative humidities will be approximately double the outdoor relative humidity.

Worthwhile reduction in heat gain to a cooled dairy cattle shelter can be achieved without appreciable increase in cost by such measures as generous natural ventilation of uncooled attic spaces, painting the exterior surfaces of concrete block masonry walls white, and use of granular core filling in concrete block masonry walls. The use of exhaust fans does not appear worth while as a nighttime supplement to cooling equipment.

Open-front shelters can be made more comfortable for summertime use by orienting the open front toward prevailing summer winds and by providing generous openings in the lower portion of the rear wall. A continuous opening at least 3 ft high along the lower wall is suggested. Closures obviously will be needed to provide for wintertime shelter.

Air motion has an important effect on surface temperatures of cattle by increasing the surface film coefficient. The increased heat transfer to the cow's surface with increased air motion when ambient dry-bulb temperatures are higher than the cow's surface may be offset partially by increased evaporative cooling.

No evidence was obtained that under present management practices an evaporatively cooled shelter was an improvement over uncontrolled, open-front shelter under Oklahoma conditions from the standpoint of milk produc-

(Continued on page 107)

Design of Subirrigation Systems

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More extensive use of subirrigation is likely, if principles and applications were more fully understood, point out irrigation engineers in a report of an evaluation and application study of subirrigation systems. Design features, requirements, advantages, and even shortcomings of subirrigation are presented in this report

SUBIRRIGATION practices have developed in many areas of the United States largely through trial and error. Most irrigation engineers have shied away from this method of irrigating, even where it is adapted, largely because they have not understood the principles of subirrigation nor the limitations involved. Nevertheless a number of tracts, generally small in area, have evolved where subirrigation systems do work satisfactorily. A good many other areas are believed to exist where subirrigation, if properly designed and operated, might be the best method available.

"Subirrigation" might be defined as a method of irrigation where the water supply for the crop comes from underneath the surface of the land. It depends on creating an artificial water table and maintaining it at some predetermined depth below the ground surface. Moisture then reaches the plant roots through capillary movement upward. This method requires that the depth to water be subject to rigid control; otherwise, the depth can become too small or too great and either retard growth or stop it completely.

Subirrigation has a low labor requirement. Where subirrigation is adaptable and the system properly designed and operated, it is probably the most efficient method known from a labor standpoint.

Requirements for subirrigation

In order for subirrigation to be practical and successful, certain natural conditions must exist as follows:

- The surface soil must be of uniform texture, deep, and highly permeable.
- There must be a natural high water table or a "tight" or restricting layer in the soil profile upon which a perched or temporary water table can be developed at some depth below the normal root zone of the crops.
- The area to be irrigated must be large enough so that losses to the drainage channels in the form of return flow will not be excessive in proportion to the water required for the entire area.
- The land surface must be smooth and level or with only a gentle slope.
- Adjacent fields should be leveled to as near the same plane as possible. In no case should the difference in elevation at the adjacent field edges exceed 4 in.
- The "floor" or restricting layer in the soil profile must be reasonably parallel with the ground surface.
- An effective natural or artificial drainage system may be necessary to allow for rapid lowering of the water table and for leaching out of salts.
- If a drainage system is installed, or if one is present, checks in the drains may be necessary for proper control of the ground water.
- Both the soil and the water used for subirrigation must be relatively free of salts, particularly if the lateral movement of the water is limited and if excess water is not available for occasional leaching purposes.
- When the free surface of water containing appreciable quantities of salts fluctuates regularly in a soil, an impervious layer or lens of salt tends to develop which may retard the movement of the water. This lens is usually just a little below the level at which the "sub" is generally maintained. Deep chiseling to shatter this lens may be found to be a desirable practice.
- Where annual precipitation is low, an annual surface irrigation during the period of the year when the water table is low may be necessary for the purpose of leaching out the salts.
- During the growing season, the water table must be controlled within certain definite limits depending upon the crop-growth cycle. Few crops will tolerate widely fluctuating water tables. Therefore, its position should not be allowed to change materially, especially during the middle of the growing season.
- Adjacent farmers must agree as to the desirable position of the water table for different times during the season and then all strive to operate on that schedule. Thus, subirrigation may require special community cooperation.
- Some special provision may be necessary to get a crop germinated and the seedlings started on subirrigated land. This may require the temporary use of sprinklers or localized surface irrigation.

Developing subirrigation

As a basis for design of a subirrigation system, it is necessary to determine the substrata conditions by means of test borings. These borings should be tied to a common datum and the boring logs and samples analyzed to obtain the following information: *(a)* the topography of the restricting layer, *(b)* the contours of the natural water table, and *(c)* the hydraulic conductivity of the various strata above the restricting layer.

Surface topographic information need be extensive enough so that it not only shows the land areas proposed for irrigation but also the adjacent areas that may be affected by the rising water table. The location of the nearest primary streams must be mapped accurately.

Since subirrigation is dependent upon controlling the position of the water table, there must be some provision for getting the water into the soil as needed. Experience has shown that under arid conditions, parallel feeder ditches run on the contour and spaced sufficiently close to assure proper control of the water table is probably the best method. Water is run into these feeder ditches, under control, and allowed to seep out and feed the water table. These feeder ditches usually are laid out on the contour, without any slope and are closed at one end. The amount of water turned into the ditch is held to that which the soil will absorb for a given depth of water in the ditch. If more or less water is desired to raise or lower the water table, the depth of water in the ditches is controlled accordingly. If this does not give the desired water table control, a change in feeder-ditch spacing may be necessary.

In some cases, water is introduced into the soil profile through tile drains or "mole" drains. The use of tile drains for this purpose is limited because of high installation costs.

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Also, maintenance costs may be high because of the tendency for such drains to silt up. Mole drains can be used successfully only in certain organic soils under special conditions such as exist in the Florida Everglades. Mole drains are formed by drawing 6-in bullet-shaped cylinders through the soil. Under Florida Everglade conditions, the resulting hole is about 4½ in in diameter and the effective life of the mole drains is from 5 to 8 years. (1)*

In order to readily determine the depth to the water table, observation wells must be located at sufficiently close intervals. These wells might be spaced rather infrequently if the soil is uniform and the land is level or gently sloping in a smooth plane.

Operation of a subirrigation system requires that the farmer check the water level in the wells at various frequencies, such as early each morning, and adjust the inflow to his feeder ditches. This becomes a simple process once the best operating levels have been established. The water level should never be allowed to get sufficiently close to the soil surface for appreciable evaporation to occur. Most plant roots should feed only on the capillary fringe above the water table and should not be drowned out by free water.

Locations of subirrigation practice

There are a number of locations in the United States where sub-irrigation is practiced. Some of the most notable are found in California, Idaho, Utah, Colorado, and Florida.

In certain areas of the Great Lakes states of Michigan, Minnesota, Indiana, and Ohio, a practice of "controlled drainage" is used which in effect is a subirrigation practice. In this high rainfall area, the proper water table elevation is maintained by control structures in the drainage channels. Ordinarily additional irrigation water is not used.

Approximately 160,000 acres of low-lying delta lands and islands are subirrigated successfully in the Sacramento-San Joaquin Delta of California. Before being reclaimed by diking, these tracts were flooded each year by high waters from the rivers. By diking and installing a drainage system, it is possible to maintain the water table at the desired elevation in the peat soils either by pumping from the drains to the river or from the river to the feeder ditches as required. The feeder ditches spaced from 150 to 300 ft apart are usually from 2 to 3 ft deep and 1 ft wide. Vertical banks are possible in the soils because of the high organic content of the soil.

On the upper Snake River in Idaho is an area of some 28,000 acres known at the Egin Bench which is sub-irrigated. The land slopes uniformly at about 0.2 percent and the soils are extremely permeable overlying impervious lava rock. A description of the area is given by Clinton (2).

The Lewiston area in Cache Valley, Utah, located between the Bear and Cub Rivers, comprises a flat table land of deep permeable soils underlain by clay at about 15 feet. Original attempts to irrigate these soils by surface methods resulted in excessive waterlogging and concentration of salts in the surface soils over parts of the bench. The construction of large open drains, improved land-leveling practices and the development of better control practices for maintaining the water table at the correct level have made crop production profitable. Israelsen (3) gives an account of subirrigation in the Lewiston area.

*Numbers in parentheses refer to appended references.

The San Luis Valley of Colorado is one of the most extensive subirrigated areas in the west containing about 135,000 acres. This area, part of which is on the headwaters of the Rio Grande, apparently has surface soils that are slightly less permeable than many other subirrigated tracts. Because of the salts in the water supplies used, special practices have been developed to maintain a proper salt balance in the surface soils and to break up the hard salt lens that forms at the point where the groundwater table is most commonly held. Subsurface or feeder ditches are normally spaced 50 to 70 ft apart and run the lengths of the fields (4).

Florida has two extensive areas where conditions are suitable for subirrigation, the Everglades and the Flatwoods of the coastal plain. Until recent years, these lands have been too wet for good production during much of each season and then too dry during the hottest part of the summer. A controlled water table through subirrigation and drainage has increased production several hundred percent.

Along the Platte River in Nebraska there are several areas where the natural water table greatly favors the production of alfalfa. Many fields in this area are surface irrigated only when the alfalfa need be reseeded.

On the Eden Valley irrigation project in Wyoming an area of sandy land within one segment of the project is being developed for subirrigation. The high intake rate and low water-holding capacity of the soil makes surface irrigation difficult and labor consuming, and since the geological and topographic conditions appear favorable, it is planned to irrigate this area by subirrigation methods.

Advantages of subirrigation

Subirrigation has several major advantages in areas where it is adapted, as follows:

- The method can be used on soils having relatively low waterholding capacities and high intake rates. Experience has indicated the difficulty of trying to surface-irrigate soils having intake rates greater than about 3 in per hr. Usually such soils will hold less than 0.75 in of usable water per foot depth of soil. Under such conditions, frequent irrigation becomes necessary and labor and water costs for any surface method soar.
- Labor requirements are low.
- Weed seed are not carried over the surface of the land by irrigation water to germinate and grow. Thus weed control is simpler under subirrigation.
- The method does not interfere with tillage practices. Cultivation is not necessary for furrowing out or preparing the land to convey the water.
- Consumptive use of water is economical.
- High crop yields are possible.

Disadvantages of subirrigation

- The method requires an unusual combination of natural conditions.
- Full cooperation of neighbors is necessary.
- Only water supplies of good quality should be used.
- Soils can become saline without careful control and adequate drainage. Drainage costs may be high.
- High fertility levels may be difficult to maintain.
- Choice of crops may be somewhat limited.

Determining if subirrigation is possible

Subirrigation is limited usually to areas where the soils are relatively permeable for a considerable depth, where surface slopes are gentle and where natural subdrainage is restricted. It must be possible to hold the water table at the desired elevations with the water supply available. Thus the first analysis is to determine the possible lateral flow

from the area when the water table is at its desired elevation.

From Darcy equation of continuity

$$q=\frac{P\,h_t\,a}{l} \qquad [1]$$

in which q = flow in cubic feet per second

P = hydraulic conductivity in cubic feet per second per square foot

a = the cross-sectional area through which flow occurs at right angles to the direction of flow in square feet

h_t/l = slope of the water table (s_w) in feet per foot.

Following is an example of estimating lateral flow:

- It is desired to maintain the water table under the area being subirrigated at a point 5 ft below the ground surface.
- Slope of water table averages about 30 ft per mile, and intersects the creek bottom which is the only natural drainageway.
- Proposed irrigated area will be at least one mile from the creek. Therefore, the slope will be $30/5280 = h_t/l$.
- The average depth to shale or tight clay is about 50 ft. Thus the maximum area through which the flow away from the irrigated area would occur per mile of perimeter would be 50 x 5280 ft.
- Assume that P for the soils is 1.0×10^{-4}.

Then $q=\frac{1}{10{,}000}\times\frac{(30)}{5280}\times\frac{5280\times50}{1}=\frac{30\times50}{10{,}000}=0.15$ cfs per mile of perimeter.

If P were as high as 1.0×10^{-3}, outflow would only be 1.5 cfs per mile during the period while the water table is highest.

Subirrigation criteria

After testing for lateral flow possibilities, and if it is practical to maintain a proper water table, it then becomes necessary to design the irrigation system to apply the water to the soil. This involves designing the feeder ditches and spacing them such that the water table under the land can be raised and maintained at the proper elevation for optimum crop growth without too much variation in the depth from the land surface to the water table.

The maximum spacing between subditches or feeder ditches shall be such that the variation in depth between the land surface and the water table will not exceed some definite limit when the consumptive use of water by the crop is a maximum. This limit may be 6 in or more for such crops as alfalfa or small grain, but may be considerably less for potatoes or specialized crops.

If the land were level and no lateral flow occurred, then the amount of water necessary to maintain the water table at proper height would merely be equal to the consumptive use of the crop. However, there will always be some lateral flow

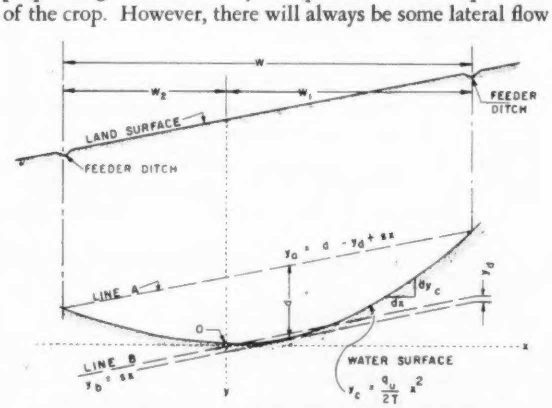

Fig. 1 Method of determining spacing between feeder ditches

if the ground water is not to become stagnant and unfit for crop production so that consideration must be given to sloping lands and water tables.

Obviously, on sloping lands, the upslope feeder ditch will supply water to a greater portion of the area between ditches. The theoretical amount supplied by each ditch and a general equation for the spacing between ditches may be determined.

Referring to Fig. 1, let

W_1 = horizontal distance served downslope from feeder ditch

W_2 = horizontal distance served upslope from feeder ditch

$W = W_1 + W_2$ = spacing between feeder ditches

s = slope of land surface in feet per foot.

It is apparent that:

(a) The origin of the x—y axis is located on the water surface curve at the point of transition between areas supplied by the upslope and downslope feeder ditches.

(b) On uniform slopes the distance from ground surface to water table at each feeder ditch will be the same and line A connecting these points will have the same slope s as the ground surface.

(c) Line B through the origin is parallel to line A and ground surface and has the same slope s.

(d) The maximum dip of water surface below line B on upslope side will be y_d.

(e) The maximum allowable variation of depth from ground surface to water table will be d.

The assumptions are made that the impervious substrata are parallel to the land surface, and the thickness of the water-saturated material is large as compared to the variation in depth between the ground surface and the water table.

If the consumptive use rate u is in acre-inches per acre per day, the flow rate in cubic feet per second to satisfy each square foot of land surface is

$$q_u = u/1{,}036{,}800 \qquad [2]$$

To meet the consumptive requirements of the crop only, the flow q passing any point x must equal the consumptive water requirements of the crop or

$$q = q_u x \qquad [3]$$

From Darcy's formula for flow in saturated soils

$$q = P s_w h \qquad [4]$$

or

$$q = s_w T \qquad [5]$$

where q = rate of flow in cubic feet per second

P = hydraulic conductivity in cubic feet per second per square foot

s_w = slope of free water surface in feet per foot

h = average thickness of water-bearing soils in feet

T = coefficient of transmissibility (Ph) in cubic feet per second per foot.

Equating [3] and [5]

$$q = q_u x = s_w T \text{ or } s_w = q_u x/T \qquad [6]$$

Also $s_w = dy/dx = q_u x/T$

$$y = (q_u/T)/\int x\,dx = q_u x^2/2T + c$$

and when $x=O$, $y=O$, and $c=O$.

Thus the equation for the water surface is

$$y=q_u x^2/2T \text{ or } x=\sqrt{2Ty/q_u} \quad [7]$$

The following equations may also be written

Line A $\quad y_a=d-y_d+sx \quad [8]$

Line B $\quad y_b=sx \quad [9]$

Water surface curve from equation [7]

$$y_c=(q_u/2T)x^2 \quad [10]$$

Differentiating equation [10], the slope of the tangent to the water surface is

$$dy_c/dx=(q_u/T)x$$

and where the water curve makes its maximum dip (y_d) below line B

$dy_c/dx=s$ (the slope of lines A and B)

So $(q_u/T)x=s$ and $x=sT/q_u \quad [11]$

When $x=sT/q_u$, $y_d=y_b-y_c$

or $y_d=(s^2T/q_u)-(s^2T/2q_u)=s^2T/2q_u \quad [12]$

Using equation [12] for the value of y_d, the equation of line A becomes

$$y_a=d-(s^2T/2q_u)+sx \quad [13]$$

Where x is the proper distance for location of feeder ditch

$$y_a=y_c \text{ or } y_c-y_a=0$$

Thus $(q_u/2T)\,x^2-sx+[(s^2\,T/2q_u)-d]=0 \quad [14]$

By quadratics

$$x=\frac{s\pm\sqrt{s^2-s^2+(2q_ud/T)}}{(q_u/T)}$$

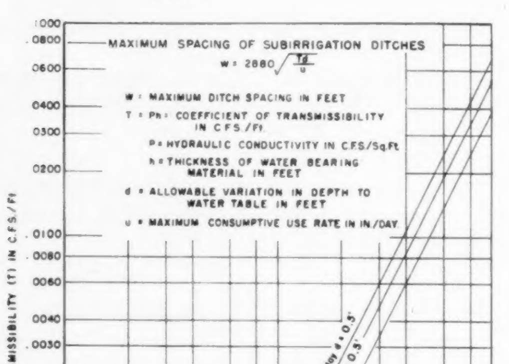

Fig. 2 Various values of spacing between feeder ditches for different coefficients of transmissibility and consumptive-use rates

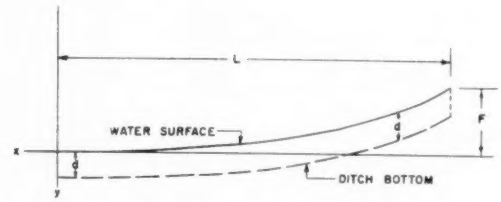

Fig. 3 Method of determining desired grade of feeder ditch

$$=sT/q_u\pm\sqrt{2Td/q_u} \quad [15]$$

Upslope $x=+W_1$

so $W_1=sT/q_u+\sqrt{2Td/q_u} \quad [16]$

Downslope $x=-W_2$

so $W_2=-sT/q_u+\sqrt{2Td/q_u} \quad [17]$

But $W=W_1+W_2=[sT/q_u+\sqrt{2Td/q_u}]+$
$[-sT/q_u+\sqrt{2Td/q_u}]$
$=2\sqrt{2Td/q_u} \quad [18]$

Substituting equation [2] in equation (18)

$$W=2880\,\sqrt{Td/u} \quad [19]$$

Since the term including s drops out in figuring the total spacing, $W=W_1+W_2$, it is evident that theoretically the spacing of feeder ditches on sloping land is the same as on level land.

Various values of W for different coefficients of transmissibility and consumptive use rates are plotted in Fig. 2.

Desirable slope of feeder ditches

Since the feeder ditches will be carrying considerable water at certain times of the year to bring the sub or water table up in a hurry, the ditches should be so designed that they will convey at least 20 times the amount required to satisfy the maximum use of the crop. Thus the slope of the ditch should be such that it will convey this maximum water need.

A further requirement for flow in a feeder ditch is that the grade be so proportioned so that the water depth remains constant from one end to the other. Under these conditions, the infiltration into the soil remains constant throughout its length.

Referring to Fig. 3, the desired grade can be computed. Since the ditch will absorb water at a uniform rate along its length, the flow at any point equals

$$Q=qx \quad [20]$$

where Q = rate of flow at point x in cubic feet per second
q = infiltration rate per lineal foot of feeder ditch in cubic feet per second

Since the desired infiltration rate is 20 times the maximum consumptive use of the crop, from equation [3],

$$q=20q_uW$$

When W is the spacing between feeder ditches and from equation [2],

$$q=(20u/1{,}036{,}800)\,W$$
$$1.93\ u\ W \times 10^{-5} \quad [21]$$

From Mannings' formula

$$Q=(1.486/n)\,Ar^{2/3}\,s^{1/2} \quad [22]$$

where n=coefficient of roughness

A=cross-sectional area of ditch in square feet (constant throughout its length)

r=hydraulic radius of ditch in feet (constant throughout its length)

s=slope of water surface in feet per foot

But $s=dy/dx$

$$dy/dx=n^2\ Q^2/2.21\ A^2\ r^{4/3}$$

$$y=\int (n^2\ Q^2/2.21\ A^2\ r^{4/3})\ dx \qquad [23]$$

Substituting equation [20] in equation [23]

$$y=\int n^2\ q^2\ x^2\ dx/2.21\ A^2\ r^{4/3}$$

Integrating

$$y=(n^2\ q^2\ x^3/6.63\ A^2\ r^{4/3})+c \qquad [24]$$

When $x=0$, $y=0$, and $c=0$

therefore $y=n^2\ q^2\ x^3/6.63\ A^2\ r^{4/3}$ . . . . [25]

When $x=L$, $y=F$, and substituting equation [21] in equation [25]

$$F=(0.561\ n^2\ u^2\ W^2\ L^3/A^2\ r^{4/3})10^{-10} \qquad [26]$$

For example, assume

$u=0.22$	$u^2=4.84 \times 10^{-2}$
$n=0.03$	$n^2=9 \times 10^{-4}$
$W=330$	$W^2=1.089 \times 10^5$
$L=1000$	$L^3=10^9$
$A=2.0$	$A^2=4$
$r=0.87$	$r^{4/3}=0.83$

Then $F=0.08$ ft

Since the total fall required under these conditions is well within construction tolerances, for all practical purposes, no grade is necessary.

Cross section of feeder ditches

The cross section of the feeder ditch should be so proportioned that the infiltration rate per lineal foot will equal the rate computed by equation [21]. The cross section is still further influenced by the maximum stable slope the soil permits and farming requirements. In organic soils the ditches often have vertical sides and are quite deep, while on mineral soils with pasture the ditches are sometimes wide and shallow. Feeder ditches often have a tendency to seal with continued use and have to be reworked at intervals to permit adequate infiltration. In some instances the ditches are permitted to overflow temporarily onto the adjacent area, when it is desired to raise the water table quickly. Probably the best information as to the rate of infiltration that can be expected can be obtained from field tests of existing ditches in the area under consideration. With these tests and a knowledge of the other conditions involved, a cross section can be selected which will meet the above criteria.

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Hot Weather Shelter for Dairy Cows

(Continued from page 102)

tion by lactating dairy cattle. The increased humidity resulting from evaporative cooling doubtless conditioned the performance of the cattle in the shelter. Although central Oklahoma experiences long, hot summers, daytime humidities are low, nights are relatively cool, and breezes are rather constant at an average velocity of 11.4 mph. These factors doubtless reduce the physiological stress on dairy cattle due to high daytime temperatures.

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Anhydrous Ammonia Applicators More in Demand

AGRICULTURAL engineers and farm machinery manufacturers interested in designing and making equipment to apply nitrogen fertilizers to the land should investigate the opportunities in anhydrous ammonia. When considering the cost per pound of nitrogen applied to the soil, savings to chemical companies in the preparation of anhydrous ammonia, by not converting it to other types of fertilizers, can be used by farm implement companies for the manufacture of application equipment.

The ammonia process is the lowest cost process for taking nitrogen from the air (commercially) and fixing it in a form suitable for use as fertilizer. Ammonia is the primary first product of every synthetic ammonia plant. It is the highest in nitrogen content (82.2 percent). It is the lowest in cost, per pound of nitrogen, to ship, store, handle and haul to the farm. Whether or not anhydrous ammonia at present is the lowest cost nitrogen fertilizer applied in the soil depends on rate of application and application costs.

According to the USDA fertilizer situation report for 1955-56, only 85.6 percent of all types of available nitrogen fertilizers during the year ending June 30, 1955, was bought and used by farmers. The expected supply of fertilizer nitrogen for the year 1955-56 will increase 5 percent.

The increase in the number of anhydrous ammonia plants and the solving of problems of organizing distribution, sales and delivery methods will increase the use of anhydrous ammonia and also the more pounds of nitrogen per acre on more crop acres.

Summary of a paper by ARTHUR M. SMITH, agricultural director, plant foods division, Olin Mathieson Chemical Corp., presented at a meeting of the Quad City Section of the American Society of Agricultural Engineers at East Moline, Ill., January, 1956.

Standard Versus Small-Orifice Raingages

F. A. Huff

DURING 1953-54, an observational program was carried out in Central Illinois to compare the rainfall catch obtained from four types of small-orifice gages with that from the U.S. Weather Bureau standard 8-in stick gage. The small-orifice gages, which are drawn to scale in Fig. 1, consisted of three cylindrical gages having catch diameters of 3 in, 1.15 in and 0.8 in, and a wedge-shaped gage having a rectangular catch area of 2.5 in by 2.3 in.

Two sets of the small-orifice gages were operated in conjunction with two standard 8-in gages from March to November 1953-54. The small gages in each set were installed at distances of 6 ft from the 8-in gage to form a circular pattern on level meadowland (Fig. 2). Observations were made at the conclusion of each storm.

Scatter diagrams comparing the various small gages and the standard 8-in gages are shown in Figs. 3-7. Examination of these graphs indicates that the wedge-shaped and 3-in gages compared best with the standard 8-in gage.

Results of the data analysis, in which storm size and wind speed were taken into consideration, indicate that the small-orifice gages are satisfactory for use in place of the standard 8-in gage for measuring rainfall under most circumstances. No tests of the gages were made during snowfall. The 1.15-in and wedge-shaped gages are constructed of plastic while the 0.8-in gage is made of glass, so their use is not recommended during freezing weather. The analytical results are summarized in Table 1, where median ratios of each test gage to standard gage have been grouped according to wind speed and total rainfall (storm size) at the standard 8-in gage.

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Urbana, Ill., June, 1955, on a program arranged by the Soil and Water Division.

The author—F. A. HUFF—is research meteorologist, Illinois State Water Survey, Urbana, Ill.

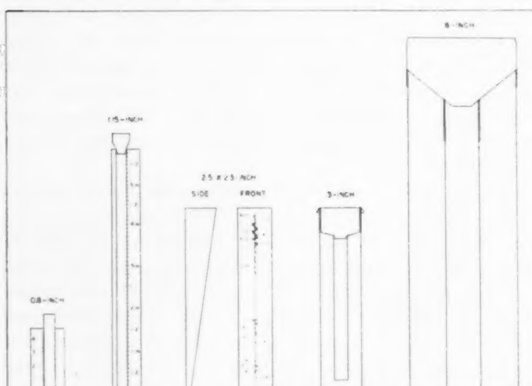
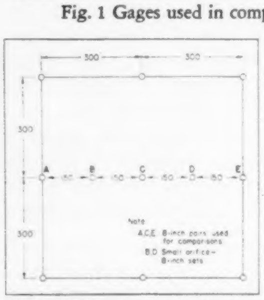


Fig. 1 Gages used in comparison study drawn to scale



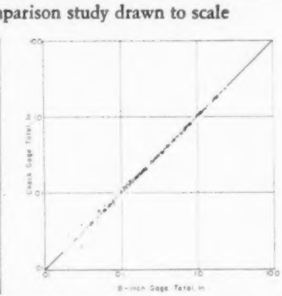


Fig. 2 *(Left)* Location of comparison gage sets with micro-network • Fig. 3 *(Right)* Comparison between 8-in gages, 6 ft apart

TABLE 1. EFFECT OF WIND SPEED AND STORM SIZE ON CATCH OF VARIOUS GAGES

Median ratio for given storm sizes compared to standard 8-in gage

Wind Speed (mph)	0.01 to 0.19 in	0.20 to 0.49 in	0.50 to 0.99 in	1.00 to 2.00 in	All storms
		2.5-in by 2.3-in gage			
0-10	1.00	0.98	0.99	1.02	1.00
11-20	1.00	0.99	0.98	0.99	0.99
		3-in gage			
0-10	1.00	1.00	1.00	1.00	1.00
11-20	1.09	1.03	1.00	0.97	1.01
		1:15-in gage			
0-10	1.15	1.03	1.00	1.00	1.04
11-20	1.25	1.02	0.96	0.97	1.02
		0.8-in gage			
0-10	1.30	1.09	1.05	1.08	1.13
11-20	1.25	1.11	1.05	1.05	1.10

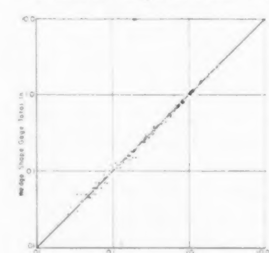
No opinion is offered regarding the absolute catch efficiency of the various gages. Comparisons were based entirely upon compatability with the 8-in gage, which is the generally accepted standard for rainfall measurements in the United States. Of the particular gages tested, the wedge-shaped and 3-in gages gave the best comparison with the 8-in gage.

Comparison with results of a rainfall gradient study (1)* indicated that the average rainfall variability in shower-type rainfall within a distance of one mile is generally greater than that observed between any of the small gages and the standard gage at a given site.

Reference

1 Huff, F. A. and Neill, J. C., Variation of point rainfall with distance, Illinois State Water Survey (1955).

*Numbers in parentheses refer to the appended references.



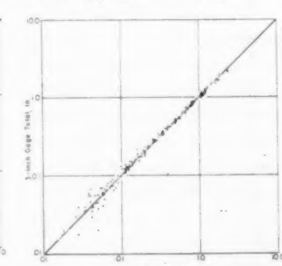
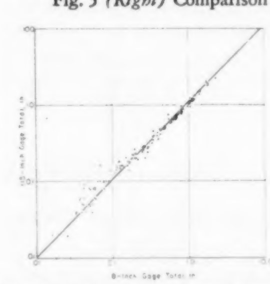


Fig. 4 *(Left)* Comparison between 8-in and wedge-shape gages • Fig. 5 *(Right)* Comparison between 8-in and 3-in gages



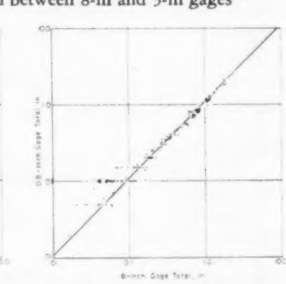


Fig. 6 *(Left)* Comparison between 8-in and 1.15-in gages • Fig. 7 *(Right)* Comparison between 8-in and 0.8-in gages

Effect of Potato Digger Design on Tuber Injury

R. Bruce Hopkins
Member ASAE

Each handling operation during the harvesting and processing of potatoes contributes mechanical injuries to the tubers. This paper is a report of a study conducted to investigate potato injuries during digging and the influence of digger design on these injuries

POTATOES are the most important horticultural crop grown in the United States in terms of the tonnage produced (3).* Maine, Aroostook County in particular, is noted for potato production. In the usual Maine harvest procedure a digger lifts the row, separates the tubers from the soil, and drops them on the ground. The potatoes are picked by hand into baskets, which are emptied into barrels, which in turn are emptied into storage bins.

Each handling operation contributes mechanical injuries. A survey of inspection certificates by Merchant, *et al.* (2) showed mechanical injuries to be the most prevalent grade defect at the shipping point. According to Schrumpf (4), in the harvest seasons of 1946 and 1947 an average of 6.8 percent of the tubers received injuries from digging; 1.2 percent were injured so severely as to be disqualified from U.S. No. 1 grade. During storage the less serious injuries may become grade defects due to drying of the tissues or the entry of decay organisms.

The continuous elevator digger is commonly used. The shovel lifts the row in preparation for its passage over the elevator where the soil is shaken out. The degree of agitation required to separate the tubers depends upon the soil characteristics, soil moisture content, and the presence of weeds. Agitation is produced by the motion of the elevator links over supporting rollers which may be replaced by irregularly shaped sprockets to improve separation. The chief differences among commercial diggers are in the location of the elevator drive and the elevator contour. Older machines particularly have the elevator sloping upward to approximately the midpoint and then downward to the rear as shown in Fig. 1. Such high-bed machines frequently have the elevator drive at the highest point. The level-bed machines have a relatively flat elevator which is usually driven from the rear. Fig. 2 shows the same machine as in Fig. 1 with the elevator in the low-bed position.

Studies of the effect of digger design and operation on mechanical injuries were made in the harvest seasons of 1950 through 1952 at Aroostook Farm, Presque Isle, Maine. The soil is Caribou gravelly loam, a well-drained soil of calcareous shale origin with a moderate concentration of stones. An International Harvester No. 16 (26 in wide) single-row digger was drawn by a Farmall H tractor. The elevator was driven by the tractor PTO through a 3-speed transmission on the digger. The Katahdin variety of potatoes was used exclusively to eliminate any differences due to varietal characteristics.

After digging, samples of approximately one bushel were taken for examination by an inspector from the federal-state inspection service. Tubers 1½ in in diameter and larger which were free from external defects such as growth cracks, scab, and sunburn were inspected for mechanical injuries. The injured tubers were classed as major, minor, or feathered depending upon the extent of the injury. A major injury consisted of a cut or other mechanical injury sufficient to disqualify a tuber from U.S. No. 1 grade†. A minor injury penetrated the flesh but did not disqualify the potato from U.S. No. 1 grade. A feathered tuber had one or more portions of the outer layer of the skin loosened or removed. The tubers bearing each class of injury were weighed, and comparisons were made on the basis of the percentage by weight bearing each class of injury.

The studies were divided into a series of separate experiments in which the effect of one of two variables was measured. To maintain other conditions constant during each test, the following were adopted as normal conditions to be followed except when studying changes in one or more of the conditions: operation of the point of the digger shovel approximately 8 in below the top of the row, a minimum of elevator agitation consistent with good separation, digger elevator in the low position, minimum height of elevator discharge, digging speed of 1.25 ± 0.10 mph, digger transmission in second speed, and tractor transmission in first speed. This combination of tractor and elevator speeds resulted in an elevator velocity of 154 fpm at 1.25 mph.

The increase in injuries as the tubers are lifted and separated from the soil with a level-bed digger was measured. It was

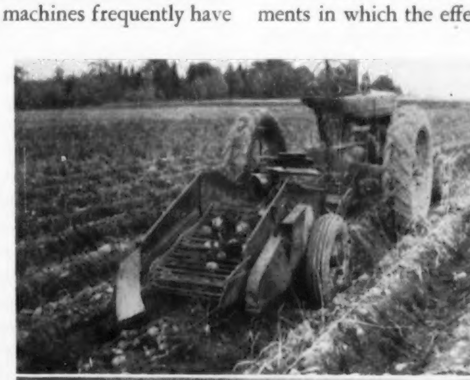


Fig. 1 *(Top)* Digger with elevator in high-bed position • Fig. 2 *(Bottom)* Digger with elevator in low-bed position

Paper prepared expressly for AGRICULTURAL ENGINEERING.

The author—R. BRUCE HOPKINS—formerly assistant agricultural engineer, University of Maine, is now an engineer at John Deere Waterloo Tractor Works.

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*Numbers in parentheses refer to the appended references.

†According to grading standards this is an injury which cannot be removed without a loss of more than 5 percent of the total tuber weight.

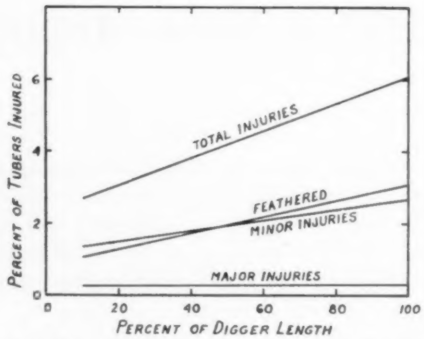

Fig. 3 Injuries increase with distance of travel over the digger

necessary to stop the digger several times and remove tubers which had passed part way over the machine. The distance which the potatoes must pass over the digger, from the front of the shovel to the rear of the elevator, was divided into five equal lengths. Each time the machine was stopped the tubers from each portion were separated from the soil and placed in containers. The data from five tests conducted under similar conditions are combined in the regression lines of Fig. 3. The regression of feathering on the basis of distance passed is significant at the 1 percent level, and the regression of total injuries (the sum of feathered, minor, and major injuries) is significant at the 5 percent level. Since the shovel constituted approximately 20 percent of the digger length, the regression lines indicate that approximately one-third of the feathering, one-half of the minor injuries, and practically all of the major injuries occurred as the tubers were lifted from the ground and started on the elevator.

Shovel Design

Schrumpf (4) reported that one-fifth of the delays causing machines to be inoperative for short periods of time were caused by stones catching in the machine. It appears that many diggers, especially those with worn shovels, operate with the elevator links digging into the ground. As a consequence, small stones are forced between the links and collect in the front of the elevator, where the stones may become wedged between a link and a supporting roller. Also the links can move larger stones upward through the gap between the shovel and the front of the elevator which may result in injuries to the tubers.

Modified shovels were devised to provide clearance between the elevator links and the ground. In the first design ¼ x 1 x 4-in bars were welded on the rear of the shovel with 1-in gaps between bars. In a later design ½-in-diam x 8-in bars were added with 1¼-in gaps between bars as shown in Fig. 4. Test results did not show a significant reduction in injuries due to the modifications, but indicated a tendency toward fewer injuries. The design with the flat bars was unsatisfactory when the soil moisture approached 25 percent because the soil bridged the gaps between bars and interfered with movement of the row onto the elevator. This difficulty

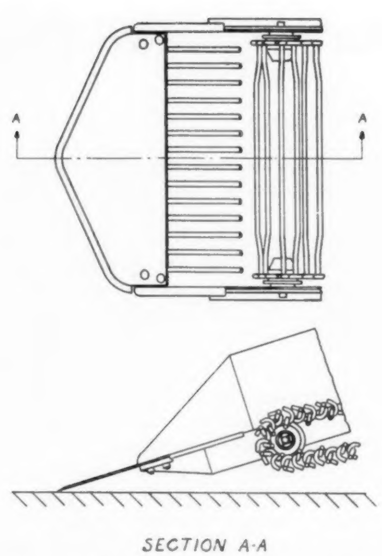

Fig. 4 Front end of digger with the shovel lengthened to increase elevator clearance

was not encountered when round bars were used. Observations during the tests and by other operators who used the modified shovels indicated that there was less frequent clogging of the elevator when either of the modified shovels was used. The disadvantage of the modified shovels consists of the large quantity of soil remaining on the shovel when it is raised at the end of a row.

Elevator Configuration and Drive Location

The machine used in the program was selected because of its design for use as either a low-bed or high-bed digger. Comparisons were made with the machine arranged as low-bed, high-bed, and an intermediate position both with the elevator driven from the rear and from the center. A randomized block split-plot design with five replications was employed. The data with regard to high-bed versus low-bed configuration are presented in Table 1. A reduction of minor injuries with the low-bed position is indicated. Differences in injuries due to drive location were not significant although there was a trend toward fewer injuries with the low-bed configuration. In a later randomized block split-plot experiment the effect of drive location with the high-bed position was measured over a range of digging speeds. Differences in major injuries and feathering were not significant. The results with regard to minor injuries are presented in Table 2. Minor injuries were significantly greater with the center drive than with the rear drive and were significantly higher at 2.15 mph than at the lower speeds. With the center drive there was a significant regression of minor injuries on digging speed which indicates an increase in minor injuries with higher speeds when a center drive is used. This is probably due to a tendency for the tubers to tumble down the slack

TABLE 1. EFFECT OF CENTER HEIGHT OF ELEVATOR ON TUBER INJURIES

Class of Injury	Position of center of elevator and percent of tubers injured: low	intermediate	high	Significant difference, 5% level
Major	0.2	0.3	0.3	N.S.
Minor	6.6	9.4	16.2	7.6
Feathered	38.9	33.4	33.6	N.S.

TABLE 2. EFFECT OF DRIVE LOCATION AND DIGGING SPEED ON MINOR INJURIES WITH HIGH-BED DIGGER

Drive Location	Digging speed in miles per hour and percent of tubers injured: 1.00	1.23	1.47	2.15	Mean
Center	14.3	13.4	16.6	24.6	17.2
Rear	12.1	12.4	12.6	15.3	13.1

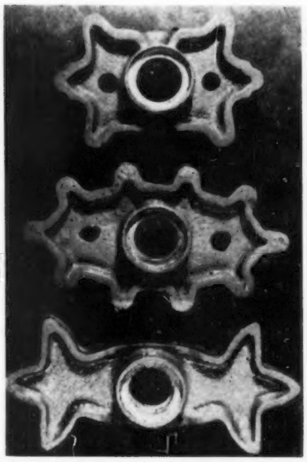

Fig. 5 Agitators used in the experiments. *(Top to bottom)* Light, medium and heavy agitators

rear portion of the elevator, especially at the higher speeds. Hardenburg and Turner (1) studied the effect of a rear auxiliary drive in New York and found that fewer injuries occurred with the drive.

Height of Elevator Discharge

The height of the discharge end of the elevator above the ground can be varied when the machine is operated as a low-bed digger. A Latin square design was used in which the vertical distance the tubers fell from the end of the elevator to the ground was varied in five steps over an approximate range of 12 to 20 in. The results of the tests are presented in Table 3. A regression analysis indicated a significant increase in minor injuries as the height of drop was increased.

Elevator Velocity and Agitation.

When the soil is wet or a field is very weedy, it is difficult to separate the tubers from the soil, and separation may be improved by adding agitators or increasing the relative elevator velocity. The latter course is followed more frequently because of the simplicity of shifting transmission gears compared to the replacement of rollers by agitators. The agitators shown in Fig. 5 were used by replacing one set of the supporting rollers near the front of the elevator with the agitators being tested. A randomized block split-plot design was employed to evaluate the effect of degrees of agitation and the three elevator speeds on tuber injuries.

The effects of elevator velocity and degree of agitation on minor injuries at a digging speed of 1¼ mph are shown by the regression lines of Fig. 6 which indicate an increase in minor injuries with either an increase in relative elevator velocity or more severe agitation. There were significantly more minor injuries with each increase in elevator velocity. In addition to significant differences among some of the agitations at second and third speeds, there also was a significant interaction between elevator speeds and agitations. Analysis

TABLE 3. EFFECT OF HEIGHT OF DROP FROM ELEVATOR ON TUBER INJURIES

Class of injury	Position of elevator rear and percent of tubers injured 1*	2	3	4	5†	Significant difference, 5% level
Major	0	0.6	0.2	0.3	0.6	N.S.
Minor	4.0	8.9	8.2	10.9	8.0	3.1
Feathered	42.2	44.1	42.5	45.6	43.1	N.S.

*Lowest position †Highest position

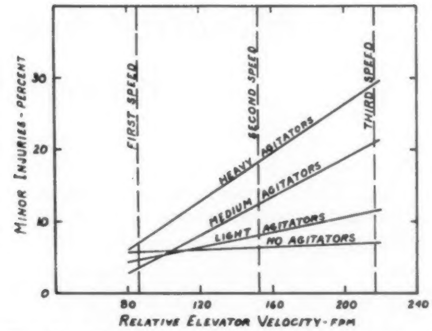

Fig. 6 The effect of elevator velocity and agitation on minor injuries

of the data on major injuries indicated significantly more major injuries with heavy agitators than with less violent agitation, and a significant interaction between agitation and elevator speeds. Soil conditions during test were such that satisfactory separation was obtained in second elevator speed without the use of agitators. Satisfactory separation with first speed was not obtained at any time during the three seasons even with very dry soil.

Agitation must be selected according to the operating conditions which may vary considerably within a field. If there are wet or weedy spots, it is necessary to select agitation which will provide satisfactory separation in the difficult spots with a consequence of excessive agitation in the remainder of the field. Although the agitation can be varied somewhat by changing the digger transmission speed on machines so equipped, it is necessary to stop the tractor to do so. Mechanical injuries could be reduced considerably if machines were equipped with an effective method of varying the agitation during operation.

Summary

In the operation of a level-bed digger nearly all the major injuries, one-half of the minor injuries, and one-third of the feathering occurred as the tubers were lifted from the ground by the shovel. Improved operation of the machine was obtained by lengthening the shovel in order to increase the clearance of the front of the elevator.

Fewer tuber injuries occurred with a low-bed than with a high-bed configuration, and with the high-bed machine there were fewer injuries when the elevator was driven from the rear. Increases in the height of the elevator discharge resulted in more minor injuries.

An increase in relative elevator velocity or a change to more severe agitation resulted in more injuries. Because differing degrees of agitation are required due to variations within fields, a need exists for an effective method of changing the agitation while the machine is operating.

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Modified Stadia Slide Rule Speeds Elevation Calculations

Leonard B. Marr

Penciled stadia slide rule saves both field and office time required to prepare a topographic map

BY PENCILING in new numbers on a standard stadia slide rule, elevations can be read directly from the rule for either positive or negative deflections of the transit. Instead of reading the slide rule to give the difference in elevation, the new system will give the exact elevation reading. Of course, the rule will have to be penciled for each H.I. (height of instrument), assuming there will be a change in H.I. for each setup.

The system varies little from standard practice. Two instruments can be operated side by side. The man at the plane table uses an alidade for taking directional shots on the rodman and plots the distances given to him by the transitman. The transitman reads on the transit the vertical angle to a fixed rod reading. He quickly computes the elevation reading by multiplying the stadia distance by the vertical angle on the slide rule and reads the elevation directly from the penciled numbers.

The plane table man pivots on his home position of the plane table to each rod of the rod readings given to him by the transitman for obtaining the line of sight, along which he plots the distance and elevation. Between successive shots he generally finds the time to sketch in salient ground features. One instrumentman can operate the two instruments, or just the alidade, with equal accomplishment. Generally, however, one rodman will wait out a portion of his time with one instrumentman. This, however, depends also upon the frequency of shots and scale of the map or both. Two instrumentmen can keep two or three rodmen busy, again depending upon each particular survey.

The advantage of the modified stadia slide rule over the conventional methods is in reducing the time required to convert stadia distances and vertical angles directly to elevations on the rule. The H.I. elevation determines the *base* from which the *A* and *R* scale modifications are calculated.

Assume that the H.I. is 262.2 ft. A slide rule base of either 250 or 260 can be used, depending upon whether it is desirable to use 12.2 or a 2.2 fixed rod reading, respectively. In either case the rod correction is automatically accounted for by virtue of deliberately shifting this base a distance of 2.2 ft (with a base of 260) to the right on the antilog scale so as to simplfy the modification by keeping all markings in units of 10 to coincide with that of the rule. This shift of 2.2 ft on the scale has the effect of reducing a parallel line of sight by 2.2 ft to the ground level. Therefore, whenever the right index of the slide is set opposite an observed distance and multiplied by the observed vertical angle, as taken from the fixed rod of 2.2, the correct penciled elevation above this point is the correct ground elevation sought.

If by coincidence the succeeding instrument position on the map has the same H.I., the rule can again be used without change. Generally, however, each instrument position has a different H.I., which requires remarking the rule, unless this succeeding change in H.I. is not greater than 10 ft. In this case the same base can still be used but at a different fixed rod such as 9.5 (H.I. 269.5, same base 260).

The procedure for modifying a stadia slide rule is simple. With an H.I. of 262.2 as previously stated, a slide rule base of either 250 or 260 can be used. A base of 240 could be used, but this would call for a rod of 22.2 ft, which is not practicable. Assume, therefore, that a fixed 2.2-ft rod will be used from which it is necessary to choose a base of 260.

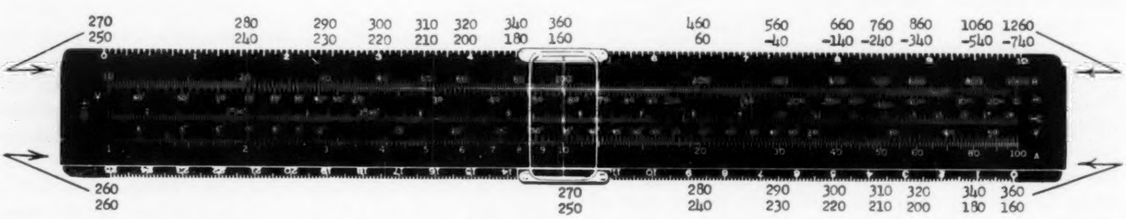

Fig. 1 Model No. 4100 (K&E) stadia slide rule used for determining elevation differences. Arrows indicate numbers to be penciled in on *A* and *R* scales for direct elevation readings

On the lower *A* scale (Fig. 1) begin on the left end at antilog 1 by lightly penciling the base 260. At antilog 10 mark 270, and progress accordingly to antilog 100 and mark 360. Each of these positive elevations are equal to the sum of the base 260 plus the antilog below which they appear. Thus the penciled elevation 280 is equal to the base 260 plus the antilog 20. For negative angles, elevations begin by using the same 260 as marked at antilog 1 and progress to the right as before, but reduce the elevations in decrements of 10 units at each antilog number. Thus, at antilog 10 appears 250, below the positive elevation of 270. At antilog 100 appears a negative and positive elevation of 160 and 360 respectively. Proof: the negative elevation of 160 plus antilog 100 equals the base 260; the positive elevation of 360 minus 100 equals the same base 260. Elevations marked at each antilog can be checked and shown to equal the base 260.

(Continued on page 120)

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Prefabricated Linings for Irrigation Ditches

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Results of two years of testing and experimentation on various types of prefabricated linings for small irrigation farm ditches reveal valuable information on installation, performance, maintenance and vegetative growth control for both buried and surface linings

INCREASED production demands, rising costs, and shortages of water in many areas have focused greater attention on efficient utilization of water. Emphasis is being placed on good water management which can be achieved by efficient water storage, conveyance, application and use.

One of the largest factors contributing to inefficient water management is seepage loss from unlined irrigation ditches. A large part of this loss occurs in the conveyance of water from the source to the farmer. Measurements by Rohwer and Van Pelt Stout (1)* and others show that these losses may amount to 20 to 40 percent of the water diverted. Some estimates place the figure as high as 60 percent.

In California there are over 21,000 miles of canals and ditches which convey water to the farm. This figure does not include the laterals and ditches of the farm distribution system. An estimate of the total length of these would be approximately 44,000 miles. Some of these are permanent, lined ditches; however, the biggest percentage are unlined sections of a less permanent nature.

Considerable experimental work has been done on different types of linings for canals and ditches of relatively large cross sectional area such as those used to convey water in irrigation districts and projects (2, 3, 4, 5, 6). Some of the criteria established can be applied to the problems involved in lining the relatively small irrigation ditches found on irrigated farms. However, there are many problems which are unique to the construction, operation and maintenance of these small ditches. They include limited farm equipment which must be adapted to the construction and maintenance of ditches, intermittent operation, temporary location due to crop rotation and cultivation practices, little or no maintenance, grazing of animals, and the use of outlets in the sides of the ditch to get the water onto the land.

The purpose of this paper is to report on the results of a research study of certain prefabricated linings for small irrigation farm ditches. Installation, maintenance, resistance to vegetative growth, seepage control and over-all desirability of the linings from the standpoint of the farmer were included in the study. The economics involved have not been included because of the experimental nature of some of the linings.

Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1954, on a program arranged by the Soil and Water Division.

The author—V. H. Scott—is assistant professor of irrigation, University of California, Davis.

*Numbers in parentheses refer to the appended references.

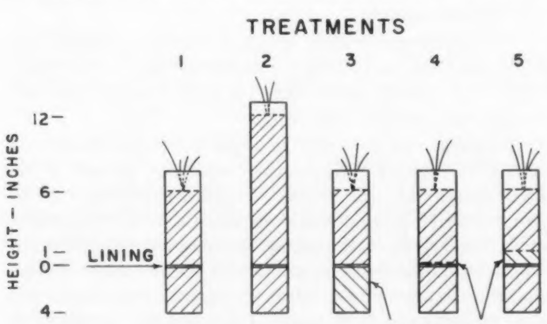

Fig. 1 Laboratory cylinder tests to determine the effectiveness of various linings in resisting penetration of plant roots growing in soil columns of different depths above the lining

Two general types of linings—buried and surface—were investigated under field and laboratory conditions. The buried linings, because of certain physical characteristics, are not able to withstand the rigors of exposure or other elements to which they are subjected when on the surface of the soil. Therefore, they require some protective soil covering. The surface linings are laid directly on the soil surface of the excavated ditch bank. Linings investigated are tabulated in Table 1.

TABLE 1. PREFABRICATED LININGS

Type		Weight (lb per sq yd)
Buried Linings		
Asphalt A	½-in catalytically air-blown asphalt with mineral stabilizer on a 60-lb kraft paper backing in 3x36-ft rolls	7.9
Asphalt B	3/32-in asphalt saturated felt with an aluminum foil selvage covering one-half of the width of a 3 x 36-ft roll	3.3
Asbestos	3/32-in asbestos fiber felt impregnated with asphalt in 3 x 36-ft rolls	3.5
Wood fiber	1/16-in twisted wood fiber woven mat coated with neoprene in 4½ x 300 ft rolls	2.4
Laminated paper	Two layer 50-lb kraft paper cemented with asphalt and reinforced with glass fibers	0.52
Surface Linings		
Wood fiber	Same as above	
Asphalt C	½-in asphalt mat in 3 x 8-ft sheets	27.0
Plastic A	8-mil white vinyl film	0.7
Plastic B	4-mil white vinyl film	0.4
Plastic C	4-mil clear vinyl film	0.4
Plastic D	6-mil black polyethylene film	0.6
Plastic E	1½-mil black polyethylene film	0.1

All of the field ditches selected for experimental installations had relatively small cross sections with side slopes of 1½ to 1 with a wetted perimeter of 4 to 6 ft depending on the rate of flow and bottom slope. These are typical of a large percentage of the small irrigation distribution farm ditches used in California.

Buried Linings

Previous experimental installations of prefabricated asphalt linings have used a 1-ft backfill. This requires moving

a large volume of soil at considerable expense. In these tests a 6-in over-excavation and backfill was used. This kept the amount of soil handled at a minimum.

The asphalt *A* and asbestos linings were laid, starting at the downstream end, across the ditch, lapped 3 in, and sealed with cold asphalt cement. The asphalt *B*, wood fiber, and laminated-paper linings were laid longitudinally. The asphalt *B* lining was lapped one-half of its width, leaving the 19-in aluminum selvage on top. The wood fiber required only one lap and was sealed with a rubber-base adhesive. The laminated paper was wide enough to extend across the ditch without a lap. This is an advantage of any material as the labor required to seal each lap is considerable, and a joint is a potential source of leakage.

A soil sterilant—43 percent sodium chlorate and 57 percent borax—was applied at different rates to the soil foundation on which the lining was laid in portions of the asphalt and asbestos sections.

Surface Linings

The surface linings were laid on the surface of the excavated ditch following a minimum of hand labor required to remove loose clods.

The wood fiber and plastic materials were rolled out longitudinally with no laps or joints. The asphalt *C* material of ½-in by 3 by 8-ft strips were laid across the ditch section, lapped 3 in and sealed with asphalt cement. The 8-ft length extended approximately 1 ft over the berm, and this was covered with soil.

Laboratory Study

A laboratory program was carried out to ascertain certain characteristics of the linings. The objective of a cylinder study (Fig. 1) was to determine the effectiveness of the linings in resisting penetration of plant roots, growing in the soil columns of different depths above the lining, in combination with the placement of a soil sterilant above or below the lining.

After the plants had grown in the containers for several months, the cylinders were stripped and the soil atomized carefully permitting the roots to be exposed. Careful examination of the lining and the root system of the plants disclosed whether the lining was able to resist root penetration.

Another laboratory study was designed to test the deterioration and change in durability of the membranes when exposed to three treatments—continuously submerged, intermittently submerged, and dry.

Six strips of each material were removed from the basins after 45 and 102 days of exposure, examined carefully, and in some cases tested for a change in durability and strength.

Results

Installation. All of the buried and surface linings required some hand labor in preparing the side slopes and bottom of the ditch sections for installation. In the case of the asphalt and asbestos materials, ambient temperature at the time of installation was important. The average temperature during installation of asphalt *A* was 75 F and considerable cracking occurred. In contrast the average temperature during installation of asphalt *C* was 95 F and even though it was ½-in thick, it conformed to small irregularities due to increased pliability produced by the high temperature. The temperature at the surface of the material was measured to be 110 F.

Temperature can also influence labor time required to apply the adhesive used in sealing the laps of the asphalt and asbestos linings. High temperatures permitted rapid application and spreading, reducing the time required approximately 25 percent. Temperature had little or no effect on the ease of installing the other linings.

The overexcavation necessary for the buried-type linings requires considerable hand or machine work, unless a readily available soil stockpile is nearby and can be brought economically to the ditch site and backfilled onto the lining. To provide an average backfill depth of 6 in requires approximately 5 cu ft of excavation per linear foot for a ditch with a wetted perimeter of 4 ft. This assumes the side slopes cut by a conventional ditcher are flat enough to insure a natural angle of repose for the backfill material. It was found that the maximum slope in a loam soil was 1½ to 1. Flatter slopes are desirable particularly where wave action or high velocities are anticipated.

Labor requirements for the asphalt *B* which had longitudinal joints but with a 19-in lap required approximately one-half the time required for transverse 3-in lap joints. This included the extra time for fitting the lining in and around 12-in concrete turnouts located every 25 ft along one side of the ditch bank.

Little difficulty was encountered in installing any of the surface linings on the slopes created by several passes of a 20-in ditcher. In fact, slopes steeper than 1½ to 1 were satisfactory providing at least 1 to 2 ft of lining was carried over a flat berm and covered with 3 to 6 in of soil.

When the lining is wide enough to cover the entire perimeter of the ditch, thereby eliminating joints, installation time is small. Attaching a roll of lining to the back of a vehicle which can move conveniently down the ditch while straddling it will facilitate installation. The only hand labor required is backfilling several inches of soil on the lining lying on a relative flat berm.

Performance and Maintenance Evaluation. Asphalt A. By the end of the first season, small line cracks began to appear. These became points of weakness through which plant roots penetrated. Often the root would run laterally along the surface of the lining before finding a crack of sufficient depth through which it could force itself. This phenomenon was verified in the cylinder study where 60 to 70 percent of the active roots above the lining were able to penetrate the asphalt.

The air-blown process which is used to construct this lining produces a relatively porous rather than a dense membrane. As a result plant roots are able to work their way through and penetrate the lining.

This material did serve as a fairly effective barrier for control of seepage and reducing vegetative growth in the ditch during the first season. Vegetative growth was approximately 50 percent less in the lined section. This can be attributed largely to the lining maintaining the soil above it near saturation between the intervals when water was not in the ditch, except for whatever surface evaporation and plant transpiration took place. This condition produced an unfavorable environment for most plant growth.

Vegetative growth became so dense during the second season that excessive resistance to flow of water resulted. It

was necessary to apply a diesel oil spray followed by burning to clear the banks and bottom.

During the second season beef cattle were allowed to walk through the ditch. Considerable damage was caused by the animals hoofs, particularly on the sides where the protective cover had sloughed to less than 6 in. A few punctures were made in the bottom where the soil depth was 8 to 10 in.

Gopher activity was observed in several places. Upon removing the backfill soil, several large gnawed holes were discovered. Attempts to patch the holes were not successful.

Some openings appeared in a few of the lapped joints. This is attributable to a poor bond between the kraft paper backing and mica-covered surface.

Asphalt B. The aluminum-foil selvage was laid on the top side of the asphalt. This formed a continuous-foil membrane in addition to the asphalt felt layer, except at the longitudinal lap joints. The aluminum surface was an effective barrier to root penetration. In the sections examined in the field, a few roots were found to have worked their way between the laps. These could be eliminated by incorporating a soluble toxic material in the asphalt joint cement. In a few places small breaks in the aluminum foil allowed root penetration. These breaks occurred near the end of the inside of the roll. This material does not have sufficient flexibility to withstand the tight bend of a small radius roll.

This lining was examined at the end of two seasons and was found to be in excellent condition except for the minor items mentioned above. Vegetation was approximately 50 percent less than in a control section. No gopher damage was found.

Asphalt C. From two summers' test this material appears to have considerable promise for either ditch or reservoir linings. It is tough and can withstand animal and some machine traffic. No vegetation has penetrated the membrane. Sealing the 3-in lap joints with hot asphalt followed by painting with a cold asphalt cement proved to be effective although time consuming. Laying this membrane with longitudinal joints should be satisfactory and would reduce the installation labor considerably. The 3 x 8-ft strips are about as large as hand labor can be expected to handle. Larger strips would reduce the number of joints but the additional weight would require a mechanical hoist for unloading and installing it. Because of its thickness this lining has some disadvantages in ease of handling and cost of transportation.

Asbestos. Tests and observations of this lining over a period of two years indicated it was a satisfactory buried lining. Joints sealed with a cold asphalt cement were sealed rapidly and smoothly and were firm and tight.

During the first irrigation season following installation, vegetative growth was 60 to 75 percent less in the lined than in an unlined section. However, during the second season this advantage almost completely disappeared.

Root penetration was essentially nil both in the field and laboratory cylinders. Washed-out roots were found to have moved along the surface of the membrane 1 to 2 ft without penetration. Some weeds growing on the sides of the ditch maintained themselves during intervals when water was not being carried in the ditch by their roots moving up along the lining surface and over the top of the berm into moist soil.

Wood Fiber. Test sections of this lining for two years proved to be satisfactory as either a buried or surface membrane. The neoprene surface was an effective coating if applied uniformly to the fabric. It weathered without apparent deterioration.

No root penetration was detected in any of the laboratory cylinder tests. However, one to two root penetrations per five linear feet of lining were found in the buried section. No penetrations were made in the surface section, even though some Bermuda grass was able to maintain itself in the limited amount of soil washed into the bottom of the lined ditch.

Two minor weaknesses of this material were noted. One was detected in the basin tests. Rapid deterioration of the wood fiber occurs as water is carried from the unprotected cut edges into the main body of the material. The fiber acts as a wick unless the edges are sealed by the rubber coating. In the field this can be overcome by using full widths of material which have the edges covered and protected.

A comparison of the tensile strength of the 2 x 6-in strips placed in the three basins and removed at the end of 45 and 102 days of exposure showed a significant decrease in tensile strength with an increase in the days of exposure. Continuous submersion was the most severe treatment as the tensile strength decreased to almost one-half that of the control after 102 days of exposure.

The other minor weakness is the uniformity of the rubber coating. Since the weave of the wood fiber leaves numerous small indentions, penetration of the coating into these pockets is not completely uniform. Therefore, in a few places the coating may not protect the fiber adequately from deterioration or roots may in time be able to wedge through these depressions.

Laminated Paper. This lining did not prove to be satisfactory. Soil bacteria attacked the paper within a few weeks, and deterioration was complete within two months following installation.

Proper treatment of paper to provide waterproofness and resistance to bacterial attack is no doubt possible and may be within economic feasibility. The use of plastic coated paper may offer some promise.

Plastics. The plastic films used were vinyl and polethylene. The vinyl films are produced from vinyl chloride acetate resins and contain plasticizers to make them flexible. Although flexibility is desirable, the plasticizer having a vapor pressure is extracted in time by water and embrittlement occurs. The rate of extraction depends largely on the thickness of the film.

The 4 and 8-mil white vinyl films (plastic *A* and *B*) in the field test ditch exposed to the sun and intermittent wetting and drying became very brittle by the end of the first irrigation season. Also vegetation continued to grow under the film because enough light was transmitted through the film to maintain the photosynthesis process of the plants. As a result, considerable stress developed in the film, and small tears began to develop in the 4-mil sections after three months of exposure. Once these initial openings developed, complete deterioration took place in a few weeks. The 8-mil film had sufficient thickness to withstand the stress mentioned above through the first season and may have been satisfactory through the second season if cattle had not trod

through the sections, rupturing the film in several places. The film was quite brittle by this time, however.

The 4-mil clear vinyl was much less brittle after one season than either of the white films. There were no breaks or tears. Some vegetation grew under the lining and caused some bulging, but no tears. During the winter of 1954-55 the material on the north bank of the east-west test section was exposed to direct radiation from the sun. By February or six months after installation the film became so brittle that cracks developed and its utility was completely lost. The material on the south bank although receiving some sunlight was shaded most of the time. No cracks or breaks occurred in it until May even though weeds and alfalfa grew vigorously under the film.

The polyethylene films (plastics *D* and *E*) are produced from polyethylene resins compounded from linear polymers of ethylene. They are inherently flexible, but need protection from light. This is accomplished by adding carbon black. Uniformity of dispersion throughout the film is important. Oxidation of the resins is reduced by incorporation of anti-oxidants, such as phenolic condensation products.

The observation and examination of the 1½ and 6-mil polyethylene films for two irrigation seasons indicated they retained their flexibility and were quite durable for the conditions of exposure encountered. A few small holes developed in both films, generally on the side slopes and above the water line in the ditch. The cause of these breaks is not known but could be attributed either to shrinkage in the film or possibly to rupture by animals or birds. Repair was made by placing pressure-sensitive polyethylene tape over the holes. This is not entirely satisfactory. Heat-sealing polyethylene patches with a bar or band sealer has not proven satisfactory.

By the beginning of the second year, numerous holes had developed in the 1½-mil film. In fact, it must be concluded that its useful life under these conditions of exposure and use is limited to approximately one year.

Vegetative Growth Control. The presence of any type of buried lining tended to inhibit the growth of vegetation for one reason. However, some control or manipulation was necessary during the second year. Since these linings will not stand mechanical manipulation with a 6-in backfill, some chemical control was necessary. Two applications of a diesel oil water solution, followed by burning, controlled the weeds during the second year.

Sterilization of the foundation below part of the buried linings was successful in inhibiting the movement of roots which were able to penetrate the linings. This was verified in the field and in the laboratory cylinder study. However, control is possible only if enough water is applied to carry the sterilant several inches into the soil. Otherwise the roots will move through the sterilized section and into untreated soil before absorbing enough sterilant to be toxic.

Control of vegetation by applying a sodium chlorate-borax sterilant to the backfill soil on top of a buried lining was satisfactory for only one year. Enough sterilant was leached or the sterilized soil sloughed from the side slope and carried down the ditch so that effective vegetative control was not possible during the second year. The application of a more permanent type sterilant should give better control or perhaps completely eliminate vegetation for a longer period of time. It should be pointed out that removal of all vegetation allows the backfill soil to slough more easily as there are no roots to bind and hold the soil.

The presence of a surface lining should prevent the growth of vegetation below it except as mentioned in the case of the white and clear plastic films where enough light passed through the lining.

Seepage Control

A summary of seepage control by the various types of linings is given in Table 2.

TABLE 2. SUMMARY OF SEEPAGE CONTROL (PONDING METHOD)

Lining	Mean depth in feet	Mean wetted perimeter in feet	Seepage loss in cu ft per sq ft per 24 hr	Seepage control in percent
Asphalt *A*	0.94	4.3	0.47	36
Control	0.88	4.2	0.73	
Asphalt *B*	1.09	4.8	0.28	47
Control	1.05	4.4	0.59	
Asphalt *C*	0.86	3.5	0.55	78
Control	0.55	2.9	2.48	
Asbestos	1.03	4.9	0.29	58
Control	0.90	4.4	0.67	
Wood fiber	0.90	4.1	0.45	64
Control	0.91	3.9	1.31	
Plastic *D*	1.00	4.0	0.09	96
Control	0.55	2.9	2.48	

All of the loss figures were calculated and averaged from the results of one to four ponding tests. The figures for the unlined sections represent the average of several sections for the same day. In the asphalt *A* and asbestos sections results from the lined sections with and without the sterilized treatments are combined and averaged. Actually the loss was slightly less in the sterilized sections for both linings which indicated less root activity through the sterilized portions of that section.

These data indicate that all of the linings did reduce the seepage loss when compared to unlined sections. The difference between the lined and unlined sections would be even greater if the experimental sections had been located in a more permeable soil. Nevertheless, seepage control—the difference between the seepage loss of the control or unlined section and the lined section divided by the seepage loss of the unlined section and multiplied by 100—for the asphalt *A* lining averaged 36 percent; for asphalt *B*, 47 percent; for asphalt *C*, 78 percent, and for the plastic *D*, 96 percent. The buried linings were considerably less effective than the surface linings.

Summary

1 There is a definite need for prefabricated linings in small irrigation farm ditches and reservoirs if good water management is to be accomplished.

2 Desirable characteristics of a suitable prefabricated lining include: relatively light weight, chemical inertness, flexibility, toughness, impact resistance, durability, resistance to vegetative growth, low water transmissibility, resistance to soil bacterial attack, minimum maintenance, and low initial cost.

3 Buried linings require considerable installation labor which includes over excavation, trimming and backfilling. A 6-in backfill is not adequate protection for asphalt and asbestos linings. *(Continued on page 120)*

Rainfall-Runoff Relations on Wheatland

Maurice B. Cox
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THE relation of runoff to rainfall has been studied by many investigators (1)*. Further data bearing on this subject are available from 12 years of records, 1941 to 1953, at the Wheatland Conservation Experiment Station, near Cherokee, Okla. This station occupies rolling, deep, permeable soil with favorable, fertile conditions. The cropping practice of the wheat section represented by this station is to plant wheat year after year and to plow the land as soon as possible following harvest. Additional tillages or cultivations are applied as often as the surface becomes crusted or compacted by rainfall or if grass and weeds appear in sufficient amounts to deplete the soil moisture. Since there is no way of controlling rainfall, measures are needed to take advantage of conditions as they occur. The amounts and intensities of rainfall were measured by Ferguson self-recording rain gages and checked by standard U.S. Weather Bureau gages at each of 10 locations. The rates and amounts of runoff were recorded by the use of type H, rate-measuring flumes equipped with Friez FW-1 recorders at 57 locations. The data presented, however, are from one rain gage and one runoff measuring location. The runoff measuring station (W-5) contains 7.85 acres with an average land slope of 1.52 percent. The area is generally rectangular in shape and all tillage and seeding operations are conducted as nearly as practicable on the contour. Winter wheat was grown on the area each year with no fertilizer or other soil-improving practices applied. A more complete description of the soils and the research investigational procedure was compiled in another report (3).

Analysis Procedure

This report analyzes these data by probability curves. They were derived by the method described by Potter (2), using total amounts and maximum occurrences for each season of each year. By use of this procedure, the points of a graph always form a smooth curve. Points are established for five recurrence intervals of 2, 5, 10, 25, and 50 years.

Computation:

1 Determine the coefficient of variation (C_v).

C_v = standard deviation divided by the mean Y from (4).

$$= \sqrt{N\Sigma Y^2 - (\Sigma Y)^2} / \Sigma Y$$

2 From curves in Figs. 13 and 14, pages 21 and 22 by Potter (2), select values of Y/conj. Y corresponding to computed C_v for the recurrence intervals desired.

3 Multiply the selected values of Y/conj. Y by conj. Y to obtain desired values of Y.

Paper presented at a meeting of the Southwest Section of the American Society of Agricultural Engineers at Hot Springs, Ark., May, 1955. Contribution from the Soil and Water Conservation Research Branch (ARS), U.S. Department of Agriculture and Oklahoma A. and M. College.

The author—MAURICE B. COX—is agricultural engineer, Red Plains Conservation Experiment Station, Guthrie, Okla.

*Numbers in parentheses refer to the appended references.

Rainfall-runoff relationship, gathered over a period of 12 years, on soil planted to wheat year after year

MAXIMUM SEASONAL 5-MINUTE INTENSITY

Fall season, year	Y (inches per hour)	
1941-42	3.60	
1942-43	3.84	$N =$ 12
1943-44	2.88	
1944-45	4.80	$\Sigma Y =$ 46.92
1945-46	4.80	
1946-47	2.52	$\Sigma Y^2 =$ 202.97
1947-48	2.88	
1948-49	4.56	$(\Sigma Y)^2 =$ 2,201.49
1949-50	3.00	
1950-51	7.20	Conj. $Y =$ 3.91
1951-52	2.64	
1952-53	4.20	

$$C_v = \sqrt{12(202.97) - 2{,}201.49} / 46.92 = 32.6 \text{ percent}$$

Recurrence interval (1 year in:)	Y/conj. Y	conj. Y	Y=(Y/conj. Y) conj. Y (inches per hour)
2 years	0.98	3.91	3.83
5 years	1.30	3.91	5.08
10 years	1.55	3.91	6.06
25 years	1.86	3.91	7.27
50 years	2.08	3.91	8.13

Illustrative Example:

An illustration of this procedure is given in the following example, using calculations for rain gage No. 1, Cherokee, Okla., 1941-53:

Since the crop year for the wheat area closes with harvest, the latter part of June, the year divides readily into three seasons: first, late summer and fall; second, winter; third, spring and early summer. The late summer and fall season, July through October, covers the period in the crop year when the soil is plowed, the seedbed is prepared, and the wheat is planted. During the winter or dormant season, November through February, the soil cover is comparatively thin but the wheat makes a small amount of growth. The spring and early summer season, March through June, covers the start of spring growth of the wheat until the crop is harvested. During this latter period, the surface soil becomes thoroughly settled and firm, with the drill furrows practically leveled. The surface frequently becomes somewhat crusted and the soil slightly stratified to plow depth. This condition does not become completely developed, however, until near the close of the crop year.

Rainfall-Runoff Relations

Intensities of precipitation have long been recognized as the most important single rainfall factor contributing to runoff (1). At this station, the rainfall is not well distributed throughout the year and long drought periods occur frequently between the intense rains of summer. During the winter, the rainfall generally comes in storms of long duration without intense bursts; but, in the spring and summer, the storms are frequently of short duration with high intensities. The intense rains occurring during the warm months of the

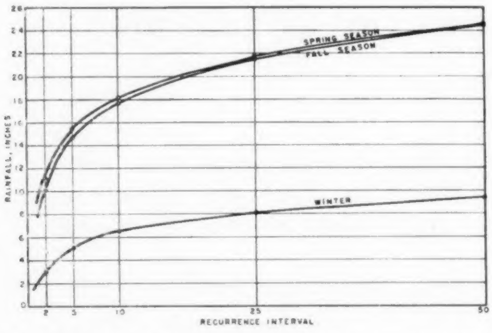

Fig. 1 Seasonal rainfall expectancies for the area near the Red Plains Conservation Experiment Station, Guthrie, Okla.

year have different intensity characteristics between the first one-half of this period and the last one-half. Differences are reflected in the rates and amounts of runoff water from these storms.

Rainfall. The average annual precipitation for the 12-year period used in this study was 25.34 in. The long-time U. S. Weather Bureau record at Cherokee, from 1915 to 1953, shows an average annual rainfall of 26.16 in. The highest rainfall for a crop year was 49.25 in during 1948-49. The lowest amount received was 15.38 in for the year 1952-53. The U. S. Weather Bureau record shows that 64 percent of the time the annual rainfall will be between 20 and 30 in; 19 percent, less than 20 in; and 17 percent, more than 30 in. The greater portion of the precipitation is received during the warm months, April through October, with the winter months of November through February generally very dry.

A storm, as defined by the U. S. Weather Bureau, is a period of precipitation in which there is no lapse of time greater than 60 min in which there is no rainfall. A total of 814 storms occurred during the 12-year period. There were 188 in excess of ½ in, 78 over 1 in, only three greater than 3 in, and none above 4 in. There was an annual average of 29 storms during the spring and early summer, 27 during the late summer and fall, and 13 during the winter.

The average seasonal rainfall for the 12-year period was 11.66 in during the spring season, 10.40 in in the fall, and 3.24 in during the winter. The probability curves shown in Fig. 1 indicate that the rainfall expectancies for the two warm seasons are close, while the winter months are dry.

The larger storms frequently contain periods of high intensities. Of the storms that were larger than ½ in, 23 percent had intensities in excess of 3 in per hr for 5-min

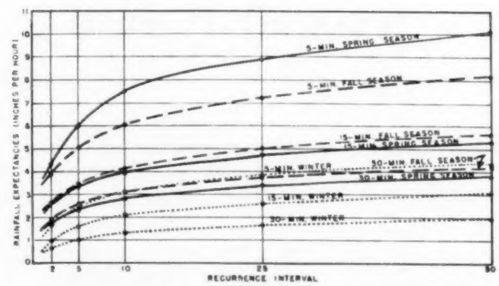

Fig. 2 Seasonal rainfall expectancies of 5, 15 and 30-min intensity

intervals, and 46 percent had intensities greater than 1.40 in per hr for 15-min intervals. The comparison of rainfall intensity expectancies given in Fig. 2 shows that the 5-min intensities are about 18 percent greater during the spring season than in the fall. By contrast, the 15 and 30-min intensities are each about 8 percent greater during the fall months than in the spring. The highest intensities generally occur during the month of June, the greatest of which were 8.44, 4.64, 3.36, and 2.68 in per hr for 5, 15, 30, and 60-min intervals, respectively.

Runoff. The expectancy for water lost in runoff as given in Fig. 3 shows that the greatest water loss occurs during the spring and early summer months. This is a period during which the 5-min rainfall intensities are the greatest and the soil surface gradually has become more compacted and crusted. Although the rains of highest intensities occur during June, there are generally more runoff periods during May. The data in Fig. 4 indicate that the peak rates of runoff are less during the spring, probably due to the growth of wheat plants and accumulation of trash on the soil surface. Since the peak rates of runoff are less and the total amounts of runoff are greater, the duration of the runoff periods is extended. This condition definitely decreases erosion of the soil surface and indicates that the rate of infiltration of water into the soil is low.

The higher peak rates of runoff expected during the fall season (Fig. 4) result in more severe erosion. These data indicate that periods of storm runoffs are of short duration with high rates. However, the total amount of water lost is less during this time (Fig. 3), since a greater part of the smaller rains and the low-intensity portions of the larger ones can be absorbed by the loose, bare soil resulting from the tillage operations. The tillage and cultivation for weed and moisture control improve the infiltration rate for at least a part of the storms or until the immediate soil surface

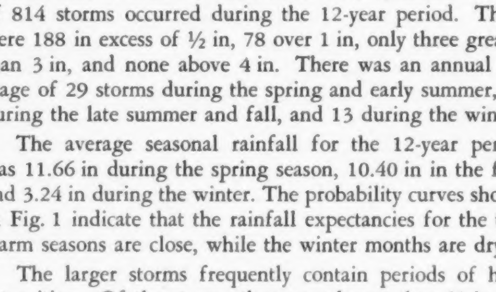

Fig. 3 Seasonal runoff expectancy

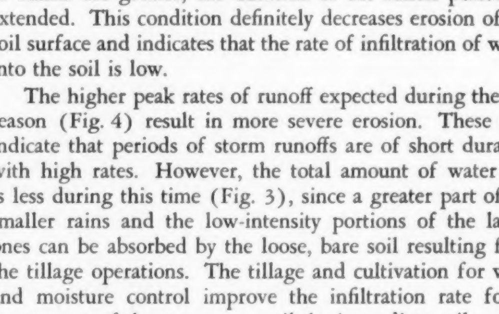

Fig. 4 Seasonal peak rates of runoff

becomes buffeted and deflocculated by high-intensity rainfall. The higher 15 and 30-min rainfall intensities during this period may also contribute to greater sealing of the soil surface when the larger rains occur.

Summary

The relation of runoff to rainfall has been studied at the Wheatland Conservation Experiment Station from 1941 to 1952. Certain data were analyzed by probability curves. The results indicate that runoff patterns and rainfall characteristics are different between the first one-half of the warm season of the year and the last one-half. Since there is no way of controlling rainfall, adjustments in cultural and cropping practices need to be made to take advantage of conditions as they occur. Large water losses are experienced during the spring and early summer. The duration of the runoff periods is also extended, due to the retarding effect of standing wheat plants. This indicates that measures are needed to invite more rapid rates of infiltration during this season. During the late summer and fall, storm runoffs are of shorter duration and less total loss but with higher peak rates. These conditions contribute to more erosion because the soil is usually bare at that time. Practices are needed to retard the rate of runoff during this season so that more of the rainfall can be absorbed into the soil.

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Modified Stadia Slide Rule

(Continued from page 112)

The antilogs on the A and R scales are used as stadia distances for multiplying by the vertical angle, on the V scales. The answers, however, are read from the penciled elevation scale. A word of caution: the negative elevations must be read in the reverse direction from the positive ones.

It will be of interest to note that in reading a constant rod of 2.2 ft, as in the foregoing example, as alternative system is offered. Use the conventional system of multiplying the distance by the vertical angle and add or subtract the results from the base 260 for the direct elevations sought.

The following example is worked by both the conventional and the modified stadia slide rule method; H.I. of transit is 262.2 ft, stadia distance is 800 ft, and minus vertical angle from horizontal line of sight to a fixed rod reading of 2.2 ft is equal to 2 deg 52 min:

Conventional method. The sine of the verticle angle of 2 deg 52 min is 0.05001. This multiplied by 800 ft stadia distance is equal to —40.00 ft. 262.2 ft—40.00 ft=222.2 ft rod which gives an elevation of 220.0 ft.

Modified stadia slide rule method. Move right index of slide to 800 ft on R scale on slide rule and move slide indicator to 2 deg 52 min on the V scale and read directly on the R scale the penciled elevation of 220.0 ft. (For an uphill or positive angle the elevation is 300 ft.)

Prefabricated Linings for Irrigation Ditches

(Continued from page 116)

4 Buried linings may be more adaptable to linings for reservoirs where conditions of intermittent wetting and drying, vegetative growth, animal traffic, and high water velocities are a minimum.

5 A chemical weed-control program is an essential part of buried lining installations since mechanical manipulation after installation is virtually impossible with present-day equipment.

6 The number of joints should be minimized so that installation costs and potential seepage loss is reduced.

7 Laminated paper is unsatisfactory for a lining unless treated for water-proofness and resistance to soil bacterial attack.

8 All of the linings except the catalytically blown asphalt essentially prevented penetration by vegetative roots.

9 All of the linings tested provided seepage control. On the basis of ponding tests, seepage control varied from 36 to 96 per cent of that loss through unlined sections. The buried linings were less effective for seepage control than the surface materials.

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4 Warnick, C. C. Experimental studies with canal linings and soil sediments for controlling seepage losses. Progress Report No. 1, Engineering Experiment Station, University of Idaho. (May 1954).

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Coarse vs. Fine-Threaded Fasteners

CONTRARY to widespread belief, fasteners with fine threads are not as strong as those with coarse threads, according to Russell, Burdsall & Ward fastener specialists. They explain that fine threads may not have the rigidity and sufficient flank engagement to carry the loads. In coarse threads, the deeper and more rugged thread will carry the load and have more uniform stress concentrations, and thus will be better able to prevent stripping.

Another frequent misconception is that fine threads stay tighter than coarse threads. Fineness or coarseness of threads has nothing to do with a fastener staying tight, R. B. & W. specialists report. The only force that keeps a joint tight is the amount of residual tension set up by torquing. The coarse threads are said to have a larger percentage of torque effort transferred into residual tension.

Another factor pointed out is that production and assembly time is saved because it requires less revolutions to tighten a fastener with coarse threads. Coarse threads enter nuts or mating holes with less tendency to cross-thread when not truly positioned and are less likely to be damaged in handling.

NEWS SECTION

J. L. Butt Becomes ASAE Secretary

JIMMY L. BUTT, associate engineer, Alabama Agricultural Experiment Station, Auburn, has been selected by the Council of the American Society of Agricultural Engineers to become the organization's new Secretary. He will assume his new duties about March 15.

Mr. Butt was born in Tallahatchie County, Miss., on October 13, 1921. He received a B.S. degree in agricultural engineering in 1943 and an M.S. degree in agricultural engineering in 1949, both from the Alabama Polytechnic Institute, Auburn. During the war years, 1943 to 1946, he served as a commissioned officer in the Field Artillery with the 63rd Infantry Division in Europe and later in the food and agriculture branch of military government in Germany. Since returning from overseas he has held several positions with the Alabama Agricultural Experiment Station. In 1946 he started as a graduate assistant. He became assistant agricultural engineer in 1948 and associate agricultural engineer in 1950. His principal area in research work has been in the field of curing, harvesting, processing and storage of seed and grain crops, hay silage and peanuts.

He has been a member of the American Society of Agricultural Engineers since 1946. He served as secretary of the Alabama Section of ASAE for five years (1949-54), and as chairman of the crop processing committee of the ASAE Southeast Section in 1951-52. He holds membership in the following societies: Tau Beta Pi, Phi Kappa Phi, Sigma Xi, Gamma Sigma Delta, Alpha Zeta and Omicron Delta Kappa. He is a member of the Methodist Church.

He is immediate past-president of the Auburn Lions Club, chairman of the Auburn Community Chest Budget Committee, and president of the Auburn Inter-Club Council. As an undergraduate he served as president of the API student body, Class of 1943.

He is married and the father of three children who are seven, five and three years of age. Mrs. Butt is the former Jane Williams of Wetumpka, Ala., and a former student of the University of Alabama.

JIMMY L. BUTT

Dairy Engineering Conference

THE Fourth Annual National Dairy Engineering Conference will be held March 13 and 14 at Kellogg Center, Michigan State University, East Lansing. The theme chosen for the two-day conference is More Profits Through Better Engineering.

The topic of the morning session, March 13, is entitled Answers to Your Refrigeration Problems. Such subjects as hold-over plates and evaporator units, cold storage doors, and checking performance of refrigeration systems are on the morning program. The afternoon program consists of a panel discussion on packaging and filling problems in small and medium sized dairies. It will be followed by a talk on the latest developments in treatment of dairy wastes and another on water pollution control legislation of interest to the dairy industry.

During the second day, the morning will be devoted to a panel discussion and three papers on dairy plant automation. The afternoon program will consist of four papers on product handling and treatment. Printed programs may be obtained by writing to Carl W. Hall, agricultural engineering department, Michigan State University.

Journal Binding Deductible in Income Tax Returns

AFTER first receiving word from a district office of the Director of Internal Revenue that binding of copies of AGRICULTURAL ENGINEERING was not deductible in income tax returns, a follow-up by an ASAE member who is engaged in teaching received a modification of the original ruling.

The new ruling stated that Section 162 of the Internal Revenue Code of 1954 provides in general that there will be allowed as a deduction all the ordinary and necessary expenses paid or incurred during the taxable year in carrying on any trade or business. Under this section of the Internal Revenue Code, the subscription price paid by a taxpayer for a technical magazine or trade journal to be used by him as means of furthering his business interest, is deductible as a business expense (O.D. 785, 4CB 130). Further, the cost of technical books required by teachers in connection with their professional work is a capital expenditure recoverable through depreciation. (Section 263, 1954 Code, and I.T. 3448, 1941-1 CB 206.)

In this case the district office determined that the cost of a subscription to AGRICULTURAL ENGINEERING is an allowable deduction as a business expense, and that the expense of binding the publication for permanent reference purposes would constitute a capital expenditure recoverable through depreciation.

The Internal Revenue Service in Bulletin F has fixed the useful life of 30 years for professional libraries as being applicable in the ordinary case. Under the straight-line method of depreciating property, for example, this would permit income tax deductions through capital depreciation at a rate of 3⅓ percent annually.

ASAE Meetings Calendar

February 18—OHIO SECTION, Dayton Power and Light Co., Route 25, one mile south of Miamisburg.

March 2 and 3—SOUTHWEST SECTION, Grim Hotel, Texarkana, Tex.

March 9 — QUAD CITY SECTION, American Legion Club, Moline, Ill.

March 30 and 31—ROCKY MOUNTAIN SECTION, New Mexico College of A. & M. Arts, State College.

June 17-20—49TH ANNUAL MEETING, Hotel Roanoke, Roanoke, Va.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

ACSM-ASP to Hold Meetings in March

THE 16th annual meeting of the American Congress on Surveying & Mapping will be held March 18 to 21, and the 22nd annual meeting of the American Society of Photogrammetry will be held March 21 to 24, both at the Shoreham Hotel, Washington, D.C.

Registration will entitle admission to all technical sessions during the entire week. Information concerning papers, speakers, dignitaries, officials, or programmed events can be obtained from Thomas E. Blount, chairman, publicity committee, Suite 1027, Cafritz Bldg., Washington, D.C.

With the ASAE Sections

Ohio Section

A meeting of the Ohio Section of ASAE will be held February 18, at the O. H. Hutchings Station of the Dayton Power and Light Co., located one mile south of Miamisburg on Route 25 and Chautaugua Road.

Following registration at 9:30 a.m., a tour of the generating plant is planned. E. D. Smith, assistant to the commercial manager, Dayton Power and Light Co., will welcome the group at a noon luncheon given by the company. D. M. Byg, secretary, O.F.E.C. and extension agricultural engineer, Ohio State University, will explain the function of the Ohio Farm Electrification Council.

The afternoon program will consist of two interesting papers. J. D. Williamson, assistant manager of power production, Dayton Power and Light Co., will talk on maintaining efficiency to provide better rural service. William Schnug, rural service supervisor, Ohio Power Co., will discuss problems encountered in applying improved electrical practices on the farm. D. L. Garber, supervisor, rural department, Dayton Power and Light Co., will serve as program chairman.

Southwest Section

The Southwest Section will meet March 2 and 3 at the Grim Hotel, Texarkana, Texas. An interesting and fast-moving session has been promised by the program committee.

ASAE President Wayne H. Worthington will address the group. Other speakers on the program include T. E. Hienton, head, farm electrification section, (AERB, ARS), USDA, Beltsville, Md., who will speak on Around the Corner in Rural Electrification; C. W. Nessell, Mt. Prospect, Ill., who will talk on the Austin Air Conditioned Village —What We've Learned; Price Hobgood, agricultural engineering department, A. & M. College of Texas, whose topic is New Methods for Tilting Concrete Slabs, and M. E. Morris who will describe a new approach to plant irrigation needs. Also planned are panels on Farm Machinery Research in the Southwest and on Irrigation.

Michigan Section

The Michigan Vitrified Tile Co., Corunna, Mich., invited and served as host to 49 U.S. Soil Conservation men at the Michigan Section meeting held January 20 at the Owosso City Club, Owosso, the purpose being to familiarize these men with the functions and activities of the American Society of Agricultural Engineers and to interest them in applying for membership.

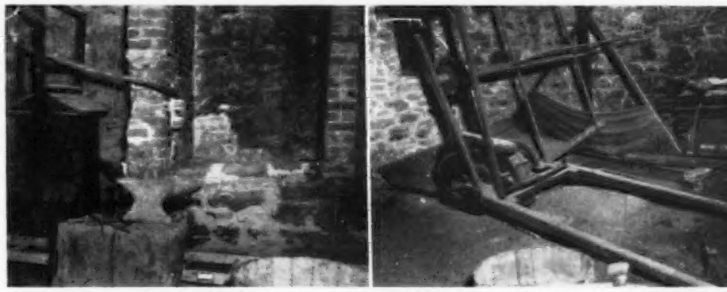
The program was of special interest to those having soil and water interests. George D. Scarseth, American Farm Research Association, spoke about food and fiber and the role of the American farmer as the producer of the food and fiber necessary for the livelihood of not only Americans but many foreign people. E. H. Kidder, Michigan State University, discussed land and water utilization; Dale Friday, nitrogen division, Allied Chemical and Dye Corp., spoke on today's fertilizers, and Henry N. Luebcke, J. E. Greiner Co., reviewed improved agricultural drainage through better highway design. The meeting was highlighted by a tour of the Michigan Vitrified Tile Company's plant to observe the manufacture of draintile.

Quad City Section

Nearly 200 persons were in attendance at a dinner meeting of the ASAE Quad City Section held January 20 at the American Legion Club in East Moline, Ill.

Ernest C. Carlson, chief engineer, advanced engineering dept., International Harvester Co., Chicago, spoke on a system of simplified drafting. Since the system has been introduced by his company, savings in both time and paper have been remarkable. The second speaker, Arthur M. Smith, chief agriculturist, Olin Mathieson Chemical Corp., gave a convincing argument why anhydrous ammonia is the No. 1 nitrogen fertilizer. He pointed out that new, better, and additional types of anhydrous ammonia application equipment are needed. In the development of such equipment, implement manufacturers can gain in equipment sales, the savings in cost necessary to convert anhydrous ammonia, the primary first product, to other types of fertilizers.

An Opportunity to Visit the McCormick Memorial



(Left) Anvil and forge in Cyrus McCormick's shop. *(Right)* Replica of the original McCormick reaper on exhibit at the Cyrus Hall McCormick Memorial

Members and friends of the American Society of Agricultural Engineers will have an opportunity to visit the Cyrus Hall McCormick Memorial while traveling to or from the 1956 ASAE Annual Meeting to be held June 17 to 20 at Roanoke, Va.

The memorial is located on U.S. Route 11, in the Shenandoah Valley, Rockbridge County, Va., on the Walnut Grove Farm near Steel's Tavern, where Cyrus Hall McCormick was born and where he later held a demonstration of his first successful reaper in July, 1831.

The shop and the old mill, where development work on the reaper was done, still stand. The 644-acre farm has been given to the Virginia Polytechnic Institute by a grant of the McCormick Foundation, and the old mill and shop are being restored as memorials to one of the world's first agricultural engineers.

In 1928 the VPI Student Branch of ASAE erected a monument near the shop building bearing the inscription: "Cyrus H. McCormick, inventor of the reaper, was born on this farm, Feb. 15, 1809. Here he completed the first practical reaper in 1831."

Hawaii Section

John F. Cykler, agricultural engineer, Pineapple Research Institute of Hawaii, was elected as chairman of the ASAE Hawaii Section, at a meeting held January 13. He succeeds Donald M. Kinch. Other new officers include William Hart, experiment station, Hawaii Sugar Planters' Association, as vice-chairman, and Robert E. Strohman, University of Hawaii, as secretary-treasurer. The nominating committee consists of W. J. Maze, Lloyd Blomquist, and Kenji Aihara.

The first portion of the meeting consisted of a tour of the engineering facilities of the Pearl Harbor Naval Shipyard. The tour included such points of interest as machine shops, testing laboratories, electrical shops and heat-treating processes.

In the evening a dinner meeting was held at the Smile Cafe for members, wives and guests. Richard A. Duncan, experiment station, Hawaii Sugar Planters' Association, spoke on his recent trip to Peru. His talk was illustrateed with colored slides and colored motion pictures, and explained not only the technical aspects of sugar cane production and harvesting in Peru, but it gave some interesting information on the social and economic conditions and the life of the people.

Connecticut Valley Section

A great job in public relations is being done by the Connecticut Valley Section. This section in cooperation with the Massachusetts Society for Promoting Agriculture will sponsor the 1956, 4th annual, Yankee Ingenuity Contest for residents of Worcester County. The purpose of the contest is to bring out ideas and machines that have been developed by the farmers for personal use and not offered for sale.

Any resident of Worcester County, regardless of age, may enter the contest. There is no limit on the number of entries by any one contestant. However, entries

(Continued on page 142)

ASAE Section Conducts Yankee Ingenuity Contest

Shown is a winning entry in the Yankee Ingenuity Contest on display at the Union Agricultural Show in Worcester, Mass. The contest is conducted under the supervision of the Connecticut Valley Section of the American Society of Agricultural Engineers as an annual event. The purpose of the contest is to bring out the many labor-saving devices developed on farms and to reward the most ingenious and deserving of the people who developed them.

W. B. Marshall, formerly sales promotion manager, has been appointed to the new position of manager of market development and sales training, Chain Belt Co., Milwaukee 1, Wis. In his new position he will assist in the general sales management of the company as related to market potentials, marketing research, and field force sales training.

•

Daniel C. McCoy retired in October from Frigidaire Division, General Motors Corp., after 30 years of service. He started with the company as a sales engineer. He soon became zone manager and since that time has served as assistant to commercial sales manager and manager of product application and development department. He edited many company sales engineering manuals and technical publications. He was contributor to a book on freezing preservation of foods and author of several articles in trade and technical publications. He served in various years as chapter author and coauthor, associate editor and editor-in-chief of the American Society of Refrigeration Engineers' data books.

Following retirement he announced that he will be available for consultation in the fields of refrigeration, air conditioning, food technology, electronics, sales technique and sales management.

•

M. J. Taup has been appointed as administrative assistant to the vice-president of sales of Vickers, Inc., Detroit, Mich. Mr. Taup has a B.A. degree from Albion College and a degree in aeronautical engineering from the University of Michigan. He joined the engineering department of Vickers in 1935 and transferred to sales in 1939. He moved to Chicago as an application engineer in 1941, and in 1943, he was appointed district manager of that office. Prior to his new assignment, he was manager of mobile products sales in Detroit.

•

A. M. Lane has been appointed to succeed M. J. Taup as manager, mobile products sales, Vickers Inc., Detroit, Mich. Following graduation in 1936 with a B.S. degree in mechanical engineering from Illinois Institute of Technology, he spent four years as an engineer with John S. Barnes Corp. He joined the Vickers sales staff in 1940 and became an application engineer the following year. He was named district manager for eastern Detroit and northern Michigan in 1942 and moved to Rockford, Ill., to become manager there in 1946. In 1950, he was appointed midwest regional manager, the position he held prior to his transfer to the home office to assume his new responsibilities.

•

J. L. Reid has resigned as instructor in agricultural engineering at the California State Polytechnic College, San Luis Obispo, Calif., to accept the position of assistant extension engineer of the Alberta Department of Agriculture at Edmonton.

•

Charles H. Daughtrey has resigned as electrification adviser of the Colquitt County Rural Electric Co., Moultrie, Ga., to accept the position of irrigation sales engineer, which includes the design and sales of irrigation systems, with Southern Electrical Equipment Distributors at Atlanta.

•

M. Jay Shustary, who recently obtained his M.S. degree in agricultural engineering from Michigan State University, is now engaged in tractor product planning work with the Tractor & Implement Division, Ford Motor Co., Birmingham, Mich.

NEWS OF ASAE MEMBERS

W. B. MARSHALL

D. C. McCOY

M. J. TAUP

A. M. LANE

Ernest U. Gingrich has been released from active duty with the U.S. Army and is now enrolled as a student at Columbia Bible College, Columbia, S. C.

•

Arthur J. Muehling, recently released from active duty with the U.S. Air Force, is now employed as a research associate in the agricultural engineering department of the University of Illinois, Urbana.

•

David A. Brueck, who has been engaged in general farming at Battle Creek, Iowa, has accepted appointment as assistant county extension director in charge of farm and home development of the Cherokee County Extension Service, Cherokee, Iowa.

•

Robert O. Taube, formerly employed as a design engineer at the Moline Works of the Minneapolis-Moline Co., has resigned to accept a similar position with the John Deere Plow Works at Moline.

•

James S. Matthews, who has been employed as an agricultural engineer with the USDA Soil Conservation Service at Clinton, Iowa, has been transferred to Oklahoma City, Okla. In his new work he will be rated as a hydraulic engineer (hydrologist).

•

James H. Hunter has been released from active duty with the U.S. Army and is now employed as a graduate research assistant in the agricultural engineering department at the University of Maine, Orono.

•

Reuben J. Aho, who has been employed as an experimental engineer with the Oliver Corp., South Bend, Ind., has accepted a position as test engineer at the International Harvester Hinsdale Farm, Hinsdale, Ill.

•

Donald G. Jedele has been appointed as assistant professor of agricultural engineering at the University of Illinois. Prior to his new assignment he spent six years as manager of Midwest Plan Service with headquarters at Iowa State College.

John K. Buttfield, formerly employed as a sales engineer of the U.K. and Dominion Motors Pty., Ltd., is now employed by the Oliver Corp. at Cleveland, Ohio.

•

Oliver B. Hill has joined the engineering department of the J. I. Case Co., Stockton, Calif. Formerly he was employed by Capps Bros., Stockton, Calif.

•

Carl F. Morris has been promoted from research engineer to agricultural engineer in the steel buildings division of Butler Mfg. Co., Kansas City, Mo.

•

Floyd L. Herum, who has been serving as a research fellow in agricultural engineering at Iowa State College, recently accepted employment with the International Cooperation Organization and will be stationed at Baghdad, Iraq, for about 18 months.

•

Lawrence E. Creasy, formerly employed by E. I. du Pont de Nemours & Co., Wilmington, Del., has accepted a position with the Tractor and Implement Division, Ford Motor Co., Birmingham, Mich.

•

Gavin C. Bristow has accepted a position as designer with Caterpillar Tractor Co., Joliet, Ill. Formerly he held a position with the David Bradley Mfg. Works, Kankakee, Ill.

•

Adrian R. Chamberlain of Thompsonville, Mich., has been granted a Fulbright fellowship and is studying fluid mechanics at the University of Grenoble at Grenoble, Isere, France. He is an agricultural engineering graduate from Michigan State University and took graduate work in soil and water at Washington State College. He completed requirements for a PhD in civil engineering at Colorado A & M College in 1955. His wife and son have been with him in France since November, 1955.

NECROLOGY

Stanley D. Russell, consulting engineer, died March 15, 1955, after a short illness. He had been employed by the J. I. Case Company, Racine, Wis., for 16 years before retiring July 20, 1954. Since that time he had been serving as a consulting engineer for several companies. His work with the Case Company was concerned mostly with the development of hay harvesting machinery, and at his retirement he was chief engineer in charge of new hay machinery.

Mr. Russell was born in Chicago, Ill., May 1, 1899. He attended Kansas State College, Chicago Technical College, and Hamilton Institute, New York. In 1931 he joined the Ann Arbor Machine Co., Shelbyville, Ill., where he designed and field tested attachments for the Ann Arbor "pitchon" baler for conversion to a pickup baler. Later with Steel Products, Inc., Vincennes, Ind., he became engineer in charge of development of an automotive machine to cut and bale previously combined fields of grain. Under his direction three machines were built for this purpose. One was self-propelled, another was motorized, but not automotive, and the third was PTO-operated. Prior to his move to Racine, to enter employment with the Case Company, he spent six months in completing development of a coal-mining machine for the Crawford-Oliphant, Inc., Vincennes, Ind.

He is survived by his wife, Helen; one son, Reif, and a daughter.

NEW PRODUCTS CATALOGS

Tractor Has 12 Forward Speeds

J. I. Case Co., Racine, Wis., has announced the new 3-plow Case 300 tractor featuring a triple-range transmission with 12 overlapping gear speeds forward plus 3 speeds reverse. Buyers have choice of diesel engine or high-compression gas engine with models for gasoline, LP gas and distillate.

The instrument panel has hour meter, speedometer, and tachometer that shows engine rpm and PTO speed. Both general-purpose and low-profile utility models have 3-point hookup.

Gasoline engines have a 3⅜-in bore and a 4⅛-in stroke with a displacement of 148 cu in. The 4-ring pistons are of aluminum alloy and cylinder walls have wet sleeves. Exhaust valves have positive rotators. Full-load rated speed is 1750 rpm with a torque peak at 1200 rpm. The electric system is 6-v.

The diesel engine has a 4⅜-in stroke giving a 157-cu-in displacement. The electrical system is 12-v, with two 6-v batteries.

A standard transmission with 4 speeds forward and one reverse is available. PTO is optional, either in constant-running or transmission-driven types.

Rear-Attached Mower

Tractor and Implement Division, Ford Motor Co., Birmingham, Mich., has announced production of a new rear-attached mower, designed to mount as a unit on all Ford tractors. Finger-tip control is provided for lifting and lowering the cutter bar

with the tractor's built-in hydraulic system.

The new mower is available with either 6 or 7-ft cutter bars. It operates from 20 deg below to 30 deg above horizontal for mowing ditch banks, irrigation borders or irregular fields. The cutter bar stays in register through a wide range of float because the entire frame raises and lowers as the inner shoe rides over the ground.

The cutter bar, available with either under-serrated knife or smooth knife, can be raised 15 in at the inner shoe and 30 in at the outer. Transport ground clearance is 1 ft, 3 in.

Tapered roller bearings are used on the main drive, flywheel shaft and pitman pin, and needle bearings in the universal joints. A pitman arm of laminated wood, and a safety release that allows the cutter bar to swing back when an obstruction is hit are added features. Total mower weight ranges from 424 to 445 lb.

Hydraulics Catalog

The Char-Lynn Co., 2843 26th Ave. S., Minneapolis, Minn., manufacturers of hydraulic equipment, has released a new catalog which will be sent on request to any interested reader. It explains the basic purposes of hydraulic horsepower, along with a chart showing the component parts needed for the producing and control of hydraulic power.

The catalog also devotes two pages to graphs which explain load capacity, cylinder speeds, volume per stroke, plumbing size necessary for certain oil volume, horsepower required for given delivery, and pump size needed to deliver a known volume.

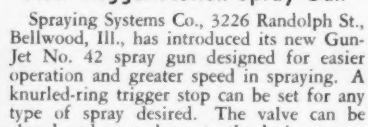
New 70-Bushel Spreader

New Idea Farm Equipment Co., Avco Distr. Corp., Coldwater, Ohio, has announced production of a new 70-bu manure spreader. Spreaders can be purchased equipped with hubs only, with wheels less

tires, or complete with 7.50-20 traction tires. Among the new features are a full-year guarantee, sides and bottoms treated with water-repellent penta, steel flares and endgate, slanted arch, phenolic bearings, and neoprene oil lines.

New Trigger-Action Spray Gun

Spraying Systems Co., 3226 Randolph St., Bellwood, Ill., has introduced its new GunJet No. 42 spray gun designed for easier operation and greater speed in spraying. A knurled-ring trigger stop can be set for any type of spray desired. The valve can be closed and opened constantly during spraying, yet the spray setting will always be the same. Any type of spray from straight



stream through full cone spray to wide-angle cone spray can be obtained by appropriate adjustment of the stop. For continuous spraying, the trigger mechanism is equipped with a trigger lock. This new model is designed for use at any pressure up to 800 lb. Stainless steel orifice disks are supplied in five different capacity ranges and are replaceable and interchangeable.

New Hay Conditioner

Deere & Company, Moline, Ill., has announced a new hay conditioner which is said to reduce hay-curing time as much as 50 percent. Curing time is reduced because large stems are kinked and bruised to allow moisture to escape at the same rate as from the leaves.

The new hay conditioner has interlocking corrugated metal rolls. These rolls pick up and kink each stem of hay at about 1½-in intervals. These corrugated, PTO-driven rolls are under spring pressure and always in mesh. The company reports that one pass through the field is all that is required to do a complete job of conditioning even in bunchy hay or uneven stands.

Filtration Manual

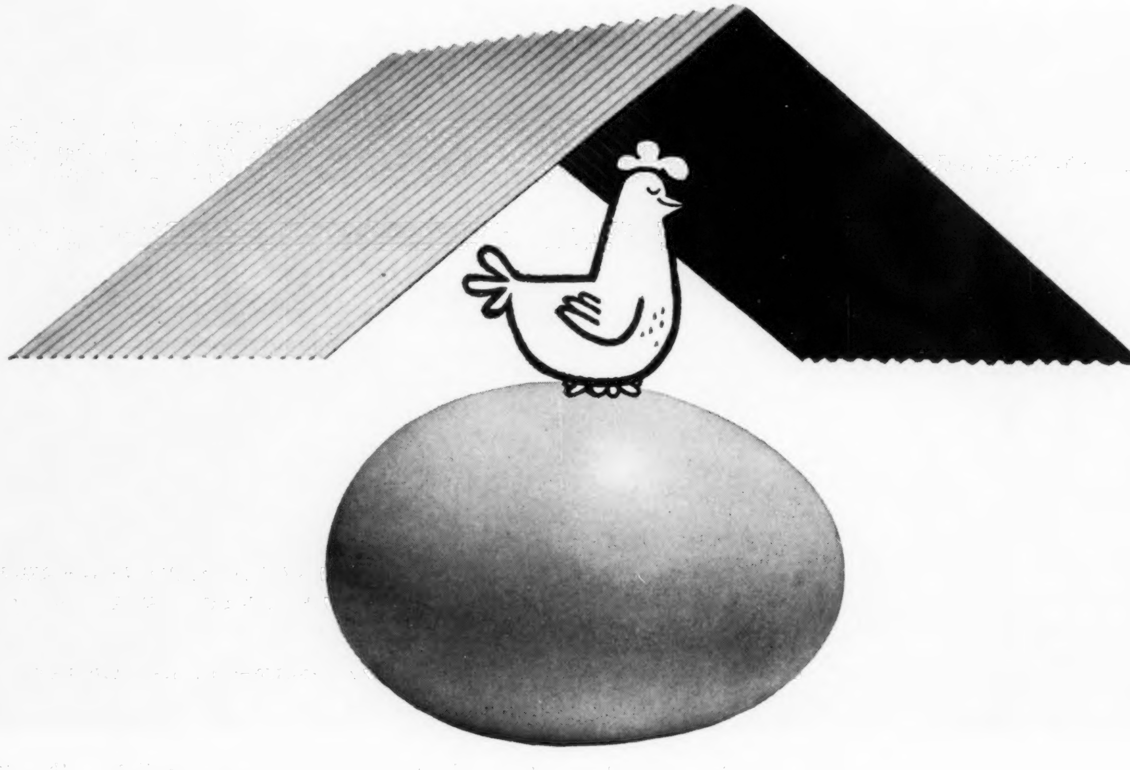
Purolator Products, Inc., Rahway, N. J., has released a comprehensive manual of filtration written especially for product designers. The new manual describes numerous filter applications and deals with such design considerations as flow rates, viscosities of fluids, and contamination to be removed, as well as filter costs, space requirements of the designer, types of filter elements and the proper selection of elements. Copies may be obtained by writing to Dept. FM, Purolator Products, Inc., Rahway, N. J. Cost is 25 cents.

New Land Leveler

The Eversman Mfg. Co., Denver 4, Colo., has announced the seventh model in its line of land levelers known as the 410. The unit is 40 ft long and 12 ft, 8 in wide, and designed for use with large wheel tractors or medium-sized track-type tractors.

The unit combines in one machine an automatic land leveler, field plane, open bottom scraper, and a tillage tool for seedbed preparation. Cutting blade width is 10

ft, cutting blade depth 21 in, blade vertical travel 16 in, and dirt capacity 2 cu yd. Features include a crank axle; front V-type smoother blade for breaking clods; front dolly assembly; front-end support for ease in hooking to tractor; screw adjustment on front truss for regulation of dirt load in blade; adjustable rear smoother blade; high-lift blade, for constructing dikes for border irrigation, and finger-tip, two-way hydraulic control of blade for field planing and dirt moving. The unit can be converted to the short form as a hydraulic scraper and with the spring-tooth attachment can be used as a tillage tool. *(Continued on page 134)*



New Products and Catalogs

(Continued from page 124)

Plug Resists Fouling

Champion Spark Plug Co., Toledo, Ohio, has developed a new spark plug designed to prevent build-up of combustion deposits on the spark-plug insulator encountered when tractors or stationary engines are used during light load or constant-speed running operations. The new 18-mm spark plug, designated the D-21, incorporates the turbo-action principle which the company introduced recently for automobiles to help overcome fouling problems in high-compression engines. The principle involves providing larger clearance volume at the firing end of the plug or greater space between the tip of the insulator and the shell of the spark plug. This is said to permit better cooling, and makes it possible for the insulator firing end to be longer, thus withstanding considerably more deposits before fouling occurs. The new plug can be installed with the conventional spark plug gasket.

Reversible Auger Teeth

Petersen Engineering Co., Santa Clara, Calif., has announced a new reversible tooth in two sizes, designed especially for use on earth-boring augers and cutting heads. The new teeth can be reversed after they are worn out on one side, and worn out again.

The boring angle is said to permit boring in most cases without any down pressure.

The new No. 49 tooth is especially designed for use on augers powered by heavy-duty boring machines and the No. 41 teeth are designed for use on medium and lightweight machines.

New Loader and Spreader

Deere & Co., Moline, Ill., has introduced new manure-handling tools with the announcement of the new 95-bu model R spreader and the new No. 45 Quik-Tatch loader.

The new spreader fits into the John Deere line between the 70-bu model L and the 120 bu, PTO-driven model N.

The new loader goes on or off any of the company's tricycle-type tractors in five minutes or less. It has a hydraulic system which requires no auxiliary oil tank.

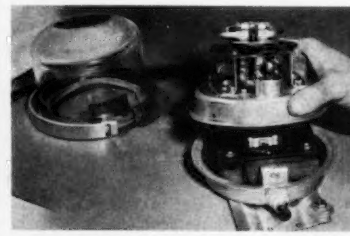
(Continued on page 136)

New Products and Catalogs

(Continued from page 134)

Mercury-Switch Fencer

Babson Bros Co., 2843 W. 19th St., Chicago, Ill., have developed a mercury-switch electric fencer that was plugged into a 110-volt outlet almost six years ago, to check the length of life of a tumbler-type mercury switch.



Today that unit still runs continuously, making and breaking contact about 86,000 times a day. The manufacturer figures that the unit has flashed about 300 million times since it was plugged in. There is no sign of wear and the 25-milliamp spark is as strong as ever.

Improved Clutch

The Rockford Clutch Division of Borg-Warner Corp., 1301 18th Ave., Rockford, Ill., has developed a new type clutch designed specifically for heavy-duty service. The new clutches are offered under the trademark name of Morlife.

Rockford engineers state that field tests show that the new clutches provide up to 100 percent more torque capacity than pre-

vious models and permit the use of smaller diameter, less expensive clutches. Also less lever or pedal pressure is required for engaging and disengaging.

The work life is said to have been increased as much as four times and heat dissipation has been improved to the extent that excessively burned or warped clutch plates have been eliminated. It is reported that torque does not fade as heat increases.

New Reference Booklet

Deere & Co., Moline, Ill., has released its new 1956 edition of *Modern Farming*, a 94-page, illustrated reference book for the tractors and farm implements manufactured by the company. Each tractor model and farm implement is illustrated by actual field scenes and the text fully describes design features and explains the function or performance for which the machine is designed.

The company reports that the booklet also could serve as a file of farming photographs which are available as glossy prints, or as flat or mat prints for use in exhibits or other purposes.

(Continued on page 138)

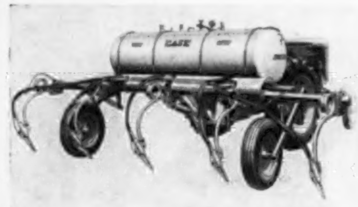
New Products and Catalogs

(Continued from page 136)

New Ammonia Applicators

J. I. Case Co., Racine, Wis., has announced two new ammonia applicators. The new Model G-8 features what are called live openers or rotating spindles used to penetrate and loosen the soil for application and covering. Rear press wheels are not required. Field tests with a mobile electronic laboratory reveal that the rotating spindles in the openers reduce draft requirements.

The drawbar hitch is designed to fit any tractor. Depth control is operated hydraulically while gauge wheels are provided with nine different positions for row-crop spacing. Double-coil spring tool shanks have safety slip joints at both ends for protection of the openers against field hazards. All tank controls and hose connections are located for easy accessibility.



Also announced is the new Model 250 with a tank carrying capacity of 250 gal. Although basically designed for use with a digger-mulcher, it can be used with a variety of forward or rear mounted tooth-type implements on tool bars. Similarly it can be used in conjunction with soil-slicing implements.

Operating controls are within reach of the tractor seat. Gages are easily viewed by the operator. Built in steps provide easy accessibility for refilling operations. Injectors are abrasion-resistant and engineered for quick disassembly when cleaning is desired. Wheel tread adjustment is provided to cover any row-crop spacing.

Hydraulic Power Lift

Wisconsin Hydraulics, Inc., 3165 N. 30 St., Milwaukee 16, Wis., has developed a new compact hydraulic power-lift unit designed for applications on mobile equipment such as snow plows, hoists, booms and tail gates. The unit consists of a 6 or 12-v d-c motor drive, pump, control valve and tank.

A rectangular housing of cast aluminum serves as the reservoir for 110 cu in of oil. The electric motor is flange-mounted to one end of the housing and the pump control valve to the opposite end. All working parts are totally enclosed.

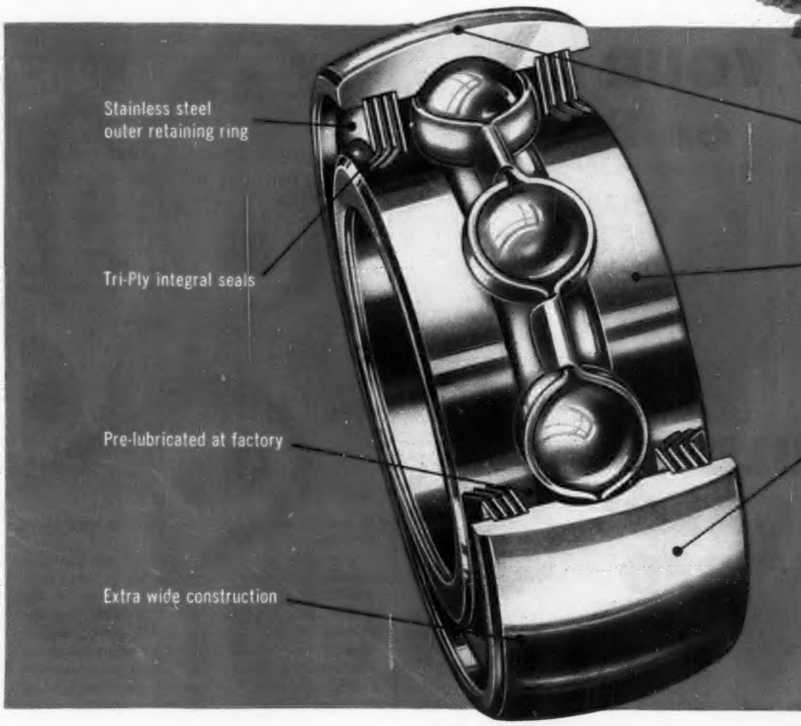
Control is obtained by one lever which can also accommodate a clevis for remote control linkage. It has three operating positions—raise, lower and spring return to hold. Lowering control is through a throttling valve for varying the rate of return. The unit can be mounted vertically, with motor end up, or horizontally.

(Continued on page 140)

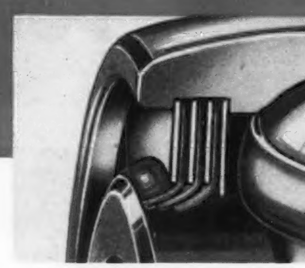
NEW! FAFNIR TRI-PLY-SEAL BALL BEARINGS

for application on

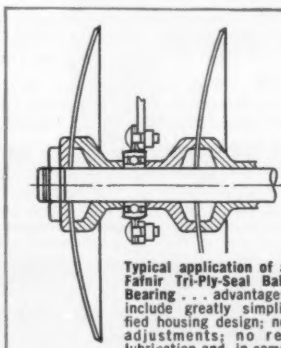
DISC IMPLEMENTS



The outstanding feature of this new Fafnir development is *its tri-ply, integral sealing.* Effective retention of lubricant and protection against contaminants have been proved by destructive tests at the factory and in the field. Test bearings have been in continuous operation for over 2500 hours in a cement dust box without any signs of failure. Variations in the standard type of Fafnir Tri-Ply-Seal Ball Bearings may be obtained to meet special housing requirements. Additional details including dimensions are available in a new bulletin. Write The Fafnir Bearing Company, New Britain, Connecticut.



Fafnir Tri-Ply Integral Seals . . . unequalled protection for ball bearings in Disc Implements



Typical application of a Fafnir Tri-Ply-Seal Ball Bearing . . . advantages include greatly simplified housing design; no adjustments; no relubrication and, in some cases, fewer bearings.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

New Products and Catalogs

(Continued from page 138)

Fuel and Cooling System Aids

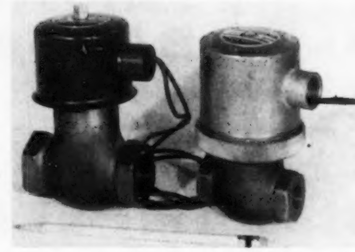
Alemite Division, Stewart-Warner Corp., 1826 Diversey Pkwy., Chicago 14, Ill., has developed two new chemical products, one to benefit fuel systems and the other for conditioning of cooling systems.

Alemite "Kleen Treet," when added to the gasoline, reportedly cleans carburetor jets of gums, keeps the fuel lines and pump free of rust and corrosion, lubricates the fuel pump and upper cylinder area, and minimizes piston deposits. It also acts as an anti-icer, preventing the formation of ice particles in the fuel system.

The second new product, cooling-system conditioner, is said to clean the cooling system and hold dirt and rust in suspension, thus preventing clogging. As well as being a rust inhibitor, it also acts as a water-pump lubricant. It is compatible with all types of water and anti-freeze, is not injurious to paint or any materials in the cooling system and is non-poisonous, according to the manufacturer.

New Solenoid Water Valve

Minneapolis-Honeywell Regulator Co., 2753-4th Ave. S., Minneapolis 8, Minn., has developed a soft-seated, solenoid-operated, floating-piston valve for a wide range of liquid or air-control applications. It is especially designed for use in humidification, irrigation and sprinkler equipment. The valve housing revolves 360 deg with electrical conduit connection. It is manufac-



tured in two sizes—½ and ¾ in—and can be equipped with either a conventional rubber seat or with a teflon seat for oil applications. Either general-purpose or explosion-proof housing is available.

The valves are rated at 115, 208 and 230-v a-c. Maximum operating pressure is 100 psi, and 1¼ psi drop is needed for full flow. The illustration shows at left a ¾-in model with general-purpose housing; explosion-proof housing is shown on ½-in type at right.

Nitrogen Solution Applicator

Tryco Mfg. Co., Inc., 1600 N. Calhoun St., Decatur, Ill., has announced the addition of the Model NST-3E applicator to its line of nitrogen-solution equipment and applicators. The trailer is identical to those used on trailer sprayers manufactured by the company. The knifing tool bar can

be purchased as a kit for addition to trailers already in the field.

For spray-on applications of agricultural chemicals, a standard boom kit is available, which can be mounted on the front of the trailer and does not interfere with the operation of the tool bar. All parts, which contact the liquid, are either aluminium or stainless steel and the nitrogen solutions are forced through a stainless steel orifice by pressure of the PTO-driven compressor.

New Rotary Chopper

Deere & Co., Moline, Ill., has announced its new multi-use No. 10 rotary chopper. Offset operation keeps the chopper and the tractor from running down the crop.

The new rotary chopper consists of a rotor with four rows of eight curved, free-swinging knives which cut a 5-ft swath.

They cut, chop, and lift the crop into a big-capacity auger where it is whisked into a blower for delivery into the trailing wagon or truck. By leaving the auger housing door open, shredded crop residues can be deposited on the ground behind the machine.

NEW BOOKS

Soil Physics (3rd edition) by L. D. Baver. Cloth, xiii+489 pages, 6 x 9 inches. Illustrated and indexed. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $7.75.

This edition has been revised and expanded to include any contributions which have been added to the knowledge of soil physics in recent years. The work begins with a discussion of the fundamental make-up of the soil and progresses through physical properties of the various soil components. Two new chapters—one on drainage and one on irrigation—include such topics as soil puddlability and compaction, chemical soil conditioners, aeration, hydraulic conductivity, soil moisture stress and wind erosion. The text is designed to show the reader how to look into the soil; to see how it is put together; and to visualize how its properties change with water, aeration, and temperature. Also it provides an understanding of the practical problems of soil management as related to the physical make-up and behavior of the soil.

The Modern Building Encyclopaedia, by N. W. Kay. Cloth, 768 pages, 6 x 9 inches, illustrated. Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y. $15.00.

The book is a compilation of material gathered from thirty expert writers, all of them specialists in their subject, including all trades and professions associated with building and the manufacturing processes applicable to the materials used. The subject matter has been selected to cover the requirements of the contractor, the craftsman, the student and the apprentice.

With the ASAE Sections

(Continued from page 121)

must have been developed for use in either production or marketing phases of agriculture. Entries are judged on the farm to select best entries in each of five categories—farm buildings, soil and water conservation, farm electrification, farm machinery and miscellaneous gadgets. Final judging will select a grand winner. Cash prizes are awarded at Farmers Field Day. Winners, if practicable, are encouraged to exhibit entries at Farmers Field Day or Union Agricultural Show. Over 10,000 people visited the Union Agricultural Show in Worcester, January 4 to 6, and had an opportunity to see the exhibit of the 1955 contest winner.

Washington Section

Wayne H. Worthington, ASAE president, was guest speaker at a meeting of the Washington Section held January 13 in Room 6962, South Building, USDA. Harold E. Pinches, assistant director, farm and land management, Agricultural Research Service, USDA, served as chairman of the meeting.

Pacific Coast Section

New officers elected at the Pacific Coast Section meeting held December 29-30, at the Student Union, University of Arizona, Tucson, are as follows: Matthew E. Hamilton, chairman; Austin A. Armer, vice-chairman; Walter W. Weir, secretary-treasurer, and Lloyd H. Lamouria, member of executive committee. V. H. Scott, Blanton E. Dunnam and Samuel J. Coughran were elected to the nominating committee.

Clarence T. Rasmussen, chairman of the 1958 ASAE annual meeting committee, reported that he had visited the Santa Barbara campus of the University of California, and that the resident houses, cafeteria, and other buildings were completed, or nearing completion. He reported that the site is admirably suited for the 1958 meeting and that the date of June 22 had been set for the opening of the meeting.

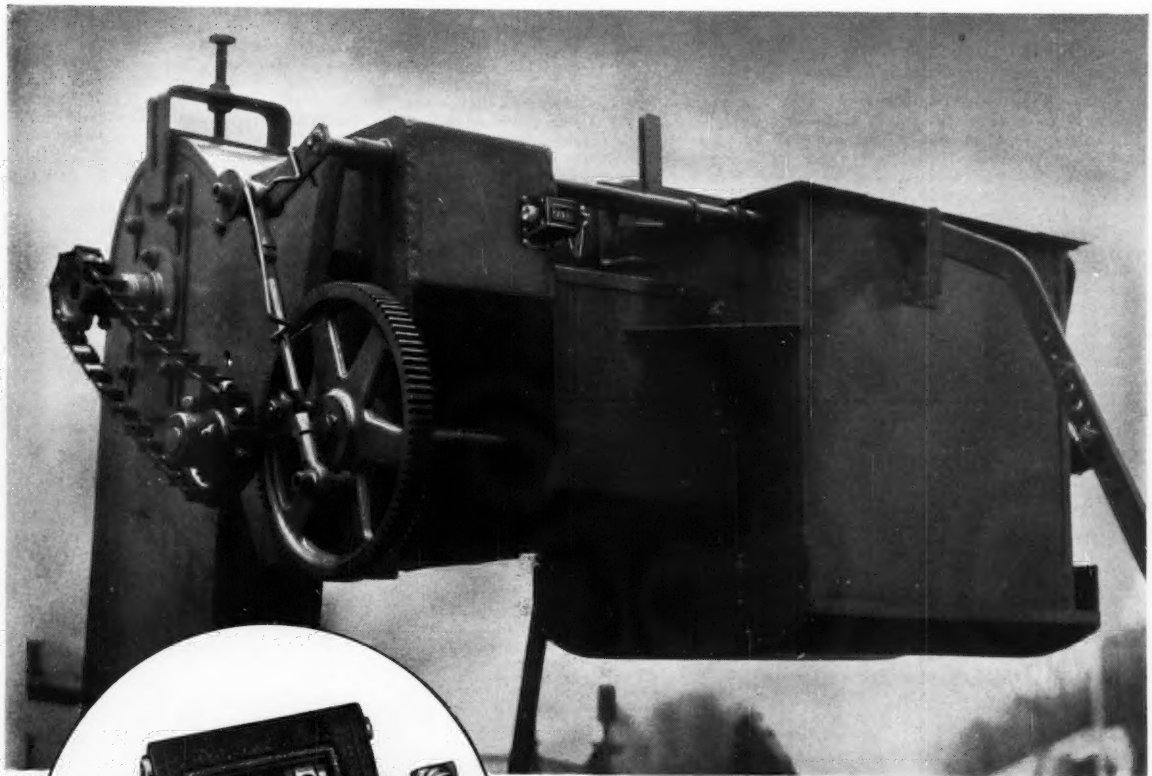
ASAE President Wayne H. Worthington spoke at the Thursday evening dinner meeting. A well-balanced program included papers on solar heat for homes, vacuum cooling of vegetables, drainage problems, small seed crop harvesting, header losses in combining, concrete tilt-up linings for trench silos, corn harvesting problems, Algerian irrigation, mechanized harvesting of cotton, irrigation wells, sprinkler evaporation losses and developments in use of 2-cycle diesel motors in small tractors.

Oklahoma Section

Fred R. Gray, construction engineer, Soil Conservation Service, USDA, Ada, was elected new chairman of the ASAE Oklahoma Section at a meeting of the Section held at the Student Union Building, Oklahoma A. & M. College, on November 18, 1955. Mr. Gray succeeds John Johns, supervisor, rural sales and service, Oklahoma Gas and Electric Co.

C. V. Phagan, extension agricultural engineer, Oklahoma A. & M. College, was elected vice-chairman, and J. P. Lonberger, district manager, Goulds Pumps, Inc., Tulsa, will serve as secretary-treasurer for the coming year.

Tentative plans are under way for the spring meeting to be held at McAlester where a field trip will be made to study some of the special features of the soil and water conservation project at the U.S. Naval Ammunition Depot.



Combine Owners:
Here's how a built-in
VEEDER-ROOT COUNTER
helps you 4 ways!

1. **IN CUSTOM COMBINING.** Counts every bushel right in the field.
2. **IN SHARING THE HARVEST.** The accurate tally tells the yield exactly, prevents arguments between landlord and tenant.
3. **IN FARM STORAGE.** Permits storing or dividing grain in the correct amounts.
4. **IN YIELD VERIFICATION.** Helps check the use of fertilizer or the advantages of summer fallow.

For accurate counting (and cost-controlling) down on the farm, Veeder-Root makes a complete line of counters which are built into tractors, hay balers, grain drills and combines. *Get the facts* whether you make, sell, buy or use farm equipment. Write for bulletin.

VEEDER-ROOT INC.
"The Name That Counts"
HARTFORD 2, CONNECTICUT
549 WASHINGTON BLVD., CHICAGO 6 • Tel: State 2-6283

NEW BULLETINS

Comparison Between Standard and Small Orifice Raingages by F. A. Huff. Circular No. 49, Department of Registration and Education, State of Illinois (Urbana). The 6-page bulletin is a report of an investigation that was undertaken to supplement existing information on the effect of gage size in rainfall sampling and to evaluate currently popular types of small orifice gages. Results of the study indicate that the small orifice gages are satisfactory for use in place of the standard 8-in gage for measuring rainfall under most circumstances. Of the particular gages tested, the wedge-shaped and 3-in gages gave the best comparison with the standard gage.

Irrigation of Russet Burbank Potatoes in Idaho by G. L. Corey and Victor I. Myers. Idaho Agricultural Experiment Station (Moscow) Bulletin No. 246 (October 1955). The 18-page bulletin reports on the effect of irrigation rate on yield and quality of russet Burbank potatoes measured over a 3-year period. Results reveal interesting information about consumptive use of water, irrigation frequency, tuber starch content, effect on disease Verticillium Wilt, pointed-end tubers, and knobby tubers. It was reported that sprinkler irrigation of potatoes resulted in a saving of water over the furrow method of 54 percent in the short-frequency plots and 60 percent in the medium treatment. The sprinkler method did not, however, produce tubers of a better grade or in a greater quantity than were produced by the furrow method.

Sod Seeding for Conservation Farming—Adaptation of Two-Row Tractor Planters, by J. T. McAlister. U.S. Department of Agriculture, Soil Conservation Service, Orangeburg, South Carolina. The 7-page, illustrated bulletin describes the use of two-row planting and cultivating equipment for use in sod seeding. Detailed procedure for adaptation of several commercial planters is included.

Measuring Farm Timber, by O. M. Davenport. University of Kentucky, College of Agriculture and Home Economics, Extension Service, Circular 533. The 60-page circular explains and describes methods of estimating board-feet volume of lumber in logs, trees, tract of timber and in a tract by species. Also included are specifications for southern pine poles and information on grading stave and heading bolts.

Earn Corn Storage in North Carolina by Sidney H. Usry, North Carolina Agricultural Experiment Station (Raleigh) Technical Bulletin No. 114 (October 1955). A 44-page illustrated bulletin reporting on studies conducted to determine most suitable frame for the storage of high moisture ear corn in North Carolina. The results of research studies conducted in both slatted and tight sidewall structures, temperature and humidity conditions within the structures, control of insect infestation, and studies of atmospheric conditions as related to the storage of ear corn.

Conveyor Feeding System for Dairy Cows in Stanchions and in Loose Housing by E. C. Schneider. Vermont Agricultural Experiment Station Bulletin 586 (November 1955). The bulletin contains a report on a conveyor feeding system for dairy cows in stanchion barns designed, built, and tested at the University of Vermont. The system is said to offer economies in labor as well as in building costs. In tests with eight cows in stanchions, as much as 58 percent of time and 77.5 percent of travel was saved by conveyor feeding as compared with hand feeding.

The Idaho Farm-Flock Laying House by C. E. Lampman, Robert E. Black, C. F. Petersen and John E. Dixon. Idaho Agricultural Extension Service (Moscow) Bulletin No. 244 (October 1955). The bulletin contains 8 pages of text that opens into a single-sheet folder containing plans for a poultry house for operation of a 500-hen laying flock. Complete details ranging from information on the type of building material to the ventilation equipment to be used in the laying house are included in the bulletin. Emphasis is placed on the best use of the farmer's time and effort. It is reported that the poultry farmer who keeps at least 500 laying hens makes the best use of his time and effort.

Electric Fences, Branding Irons and De-Horners by William H. Knight. University of Idaho farm electrification leaflet No. 29 (April 1955). The report reveals interesting information concerning the use of electricity for livestock production. Illustrations and drawings show proper installation of electric fences. A list of safety suggestions is included. Also included is a report on the use of electricity for electric branding irons and dehorners.

SIAE Bulletins. A bulletin has been received recently from the Swedish Institute of Agricultural Engineering, Ultuna, Uppsala 7, Sweden. Planning the Harvest of Ley Crops, with Special Reference to Mow Drying of Hay—Bulletin No. 263. The bulletin is written in Swedish with a summary in English. *(Continued on page 146)*

New Holland's 130-bu. Spreader shreds the densest chunks of matted material

Here's why New Holland Spreaders don't show their age

THIS big P.T.O. Spreader, with its many *exclusive* advanced features, is not only built to dish it out—but it can take it too!

You can wash down a New Holland Spreader—after weeks of work—and the finish will come up practically like new. Special steps taken during the manufacture make this possible.

For example: after all shearing, forming, piercing, notching and welding operations, metal parts are cleaned and degreased in both water and acid rinses. Remaining residue is wiped from parts by hand.

Next, a Metalife primer is sprayed over all these metal parts. This is a preservative that protects and seals against the corrosive action of bacteria, acids and weather.

This is followed by a coat of New Holland red paint. To maintain proper spray painting conditions, temperature and viscosity of paint are checked twice daily and, naturally, each time paint is mixed.

Special treatment is also given the dense Georgia pine flooring before painting. For one hour before assembly, floor boards are completely immersed in a Pentacote preservative solution—tested by the U. S. Department of Agriculture for water-repellent and non-rotting qualities. In this way even the ship-lapped joints are protected.

Add to all this the continual quality checks of materials used and you have a spreader that will wear its age well after years of service. The New Holland Machine Co., New Holland, Pa. A subsidiary of The Sperry Corporation.

NEW HOLLAND

"First in Grassland Farming"

Metal side sheets ready to be immersed in wash tank solution of 7 oz. of Fosbond 22 per gal. of water.

After 15 minutes in 180° solution, side sheets will receive hot water and acid rinses before painting.

Yellow pine floor boards draining after being submerged for one hour in fungicidal sealer bath.

NEW BULLETINS

(Continued from page 144)

Cents for Kilowatts Return Dollars to the Farm by William H. Knight. University of Idaho (Moscow), farm electrification leaflet No. 31 (October 1955). The leaflet describes what a kilowatt hour is and what a kilowatt hour can do on the farm. Also included is a complete list of the uses of electricity on the farms of the Pacific Northwest.

Electric Elevators and Conveyors Find Many Farm Uses by William H. Knight and John E. Dixon. University of Idaho (Moscow) farm electrification leaflet No. 30 (June 1955). The bulletin describes the various types of elevators and conveyors that are available for farm use. Included are belt, chain, and screw-type conveyors; bucket elevators; pneumatic tubes and liquid flow pipes; vibrators; shuttle stroke conveyors; and various types of hydraulic-lift trucks and carts. Advantages and disadvantages as well as typical applications for each type elevator or conveyor are explained.

Packing Idaho Potatoes—A Study of Plant Design, Equipment Layout and Costs by Glenn Salo and Kermit Bird. Idaho Agricultural Experiment Station (Moscow) Bulletin 247 (November 1955). The illustrated 20-page bulletin is a report of a study designed to help packers reduce packing costs. Some general principles on building design are outlined and building and equipment replacement costs are analyzed. Also discussed are fixed costs. In addition, some hints are given on plant layout. One section is devoted to new ideas in equipment.

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—1955—AUGUST—O-324-745, 334-746, 338-747, 345-748, 346-749, 346-750, 347-751, 350-752. SEPTEMBER—O-331-754, 335-756, 352-758, 372-759. OCTOBER—O-402-762, 404-764, 405-765, 409-766, 409-767, 409-768, 407-769, 407-770, 407-771, 413-772, 415-773, 394-774. NOVEMBER—O-385-775, 430-776, 439-777, 451-779, 453-780, 453-781, 454-782, 448-783, 463-784, 463-785. DECEMBER — O-401-761, 476-786, 503-787, 504-788. 1956—JANUARY—O-455-789, 534-790, 537-791.

POSITIONS WANTED—1955—SEPTEMBER—W-351-41. OCTOBER—W-383-43, 398-45. NOVEMBER — W-428-50, 429-51, 445-52, 450-53. DECEMBER—W-458-56, 486-57, 489-58, 480-59, 1956—JANUARY—W-457-60, 528-61, 529-62.

NEW POSITIONS OPEN

CHIEF ENGINEER for established farm equipment manufacturer in Mid-South. Age 35-50. BS deg in agricultural or mechanical engineering. Engineering experience in farm equipment field. Good health. Normal opportunity for advancement. Salary, $7500-10,000. O-452-792

AGRICULTURAL ENGINEERS (2 or more) for design and development of structural and mechanical equipment, including original design, field test, production design, and follow-through on pilot run with established manufacturer in Midwest. Age 25-40. BS deg in agricultural or mechanical engineering, or equivalent practical experience. Farm background preferred. Neat appearance and ability to work with production and sales groups. Desire to live in small community. Good opportunity for advancement. Salary open. O-4-601

AGRICULTURAL ENGINEER for assistant manager of architectural department of established producer of farm service buildings and equipment in Midwest. Age 25-50. BS deg in agricultural engineering, with major in farm structures, or equivalent experience. Actual experience in design or construction of farm buildings preferred. Should be able to work with sales group in presenting designs to customer. Should prefer to live in small community. Opportunity to advance to manager of department, or to sales department. Salary open. O-4-602

AGRICULTURAL ENGINEER for extension work in broad range of subject matter, with special effort in materials handling, structures and farm machinery in a northeastern state. Age 28-40. BS deg in engineering from a recognized school. MS preferred. Experience in structures, rural electric, or farm machinery extension work 3 or more years. Liking and ability for work with associates and farm people. Excellent opportunity for advancement and for organizing several new programs. Classified position with fixed annual increases, to be filled as soon as possible. Salary open. O-6-603

AGRICULTURAL ENGINEER, instructor or assistant professor rank, for teaching (25%) and research (75%) in rural electrification in an eastern land grant university. Age, under 45. BS deg in agricultural engineering, or equivalent. Related experience desirable but not required. Must have desire for research, and ability to get along with people. Excellent opportunity for advancement and for work toward MS deg. Salary $3600 or higher. O-12-604

AGRICULTURAL ENGINEER, instructor or assistant professor rank, to teach farm structures, power and machinery, and general engineering courses, in a land grant college in the West. MS deg in agricultural engineering, or equivalent. Nine-month appointment, with possibility of 12-mo basis with part time in agricultural experiment station. Excellent public schools and mild climate. Salary open. O-15-605

(Continued on page 148)

Personnel Service Bulletin

(Continued from page 146)

GRADUATE ASSISTANTS in agricultural engineering, all branches of the field, for research on tractor maintenance, silo filling equipment, silo unloading and feeding, materials handling, and runoff and drainage problems, in a land grant university in the Midwest. BS deg in agricultural engineering, or its engineering equivalent. Usual personal qualifications for advanced study and public service research. Salary $1800-2400 for half time, depending on experience and training, with ½ to ¾-time graduate study. O-29-606

AGRICULTURAL ENGINEER for development of handling and application equipment for liquid fertilizers with new organization. Western location. Field work in California, Oregon, and Washington. Age 25-35. BS deg in agricultural engineering, or equivalent. Farm background. Ability to manage own work, work independently, and cooperate closely with others. Opportunity commensurate with development of newly-formed corporation. Salary about $5400 to start. O-22-607

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for development, research, extension, sales, or writing in rural electric or product processing field, with college, manufacturer, or distributor, preferably east of the Mississippi, and north. Married. Age 27. No disability. BS deg in agricultural engineering, 1949, Pennsylvania State University. Farm background. Extension agricultural engineer 3½ yr in crop drying work; sales engineering, promotion and development engineering, with crop drying equipment manufacturer, 2¾ yr. Available on reasonable notice. Salary open. W-483-63

AGRICULTURAL ENGINEER for design, development, research, and writing; or advisory and extension work in under-developed areas, in power and machinery or product processing. Married. Age 26. No disability. BS deg in agriculture (option agricultural engineering) 1951, Macdonald College, McGill University. MS deg in agricultural engineering 1953, King's College, Durham University. Grew up in farm equipment business. Farm work experience. Currently in Malaya on investigations leading to design and development of new and improved machines and processes for the production and handling of hemp, rice, and coffee. Available in September or October. Salary open. W-506-64

AGRICULTURAL ENGINEER for sales, service, or management in power and machinery, with manufacturing or farming operation, anywhere in U.S.A. Married. Age 25. No disability. BS degs in agriculture 1955 and in mechanical engineering (expected) in 1956, University of Maine. Extensive farm work experience. Special technician, Maine Agricultural Station, summer of 1955. Enlisted and commissioned service in Corps of Engineers, 2 yr, including management experience as regimental supply and motor officer. Available July 1. W-8-1

AGRICULTURAL ENGINEER for sales, service or management in power and machinery field with manufacturer or distributor, anywhere in U.S.A. Married. Age 35. No disability. BS deg in agricultural engineering, 1949, Pennsylvania State University. Dairy farm background. Varied work experience, including office work one year, aircraft welder one year, trainee with farm equipment manufacturer 2 yr; in own farm equipment retail business 4 yr. War non-commissioned service 3 yr in Army Air Corps as welder and aircraft mechanic. Available in approximately 60 days. Salary open. W-9-2

AGRICULTURAL ENGINEER for design, development, or research in power and machinery with manufacturer in California. Single. Age 31. Impaired vision. BS deg in engineering, major in agricultural engineering, 1950, University of California. Additional study in agriculture. Farm background in California, Idaho, and Wyoming. Project engineer (GS-7) 18 mo with Navy, on development and test of heavy transportation equipment; 3 mo with U. S. Forest Service testing portable fire fighting water pumps. Design and drafting of plumbing, piping and air-conditioning for commercial and industrial building construction, 2¼ yr. War enlisted service in Army. 2 yr. Available on 30-day notice. Salary open. W-10-3

AGRICULTURAL ENGINEER for design, development, or research in power and machinery or soil and water field with experiment station or manufacturer in Midwest, Southwest, or other countries. Married. Age 32. No disability. BS deg, Ontario Agricultural College. MS deg in agricultural engineering expected in spring, Ohio State University. Farm background. Experience testing farm equipment on manufacturers test track. Soil conservation survey with Ontario government. Drainage work on Ohio State University farms. Enlisted service, Greek National Army, 3 yr. Available in May. Salary $4,800. W-14-4

AGRICULTURAL ENGINEER for advanced engineering product development in power and machinery with industry, anywhere in U.S.A. Married. Age 54. No disability. BS deg in agricultural engineering, plus 2 yr advanced work. Farm background. Research and teaching 10 yr. Private industry farm equipment and consulting engineering 20 yr. Available in 30 to 60 days. Salary open. W-18-5

AGRICULTURAL ENGINEER for extension, teaching, research, sales, or service in power and machinery with public service or industry in U.S.A., Western Canada, or elsewhere. Willing to travel. Married. Age 29. Wear glasses. BS and MS deg with specialization in agricultural mechanics, 1948 and 1950, University of British Columbia and University of Saskatchewan. Farm background. Graduate research assistant 21 mo. Assistant professor of agricultural engineering in professional curriculum in India, 5 yr. War service in Canadian Officers Training Corps. Available July 1. Salary open. W-30-6

AGRICULTURAL ENGINEER for sales, service, writing, management, farm appraisal or farm management, soil and water field, with industry, in West. Married. Age 35. No disability. BS deg in agricultural engineering, 1950, University of California. Experience as farm appraiser and farm manager, 4 yr; residential and commercial loan appraiser 1½ yr. War service 3 yr, aviation cadet and commissioned, with experience as navigator. Available now. Salary $5400. W-37-7

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Almquist, Alton W.—Agricultural engineer, land operations branch, Fort Apache Indian Agency, Whiteriver, Ariz. (Mail) Box 186

Barows, Arthur G.—Assistant advanced design engineer, advanced engineering dept., International Harvestor Co., 2919 S. Western Ave., Chicago 8, Ill.

Bartlett, George S.—Graduate student in agricultural engineering, Ontario Agricultural College, Box 41, Guelph, Ont., Canada

Bilanski, Walter K. — Graduate research assistant in agricultural engineering, Michigan State University, East Lansing

Bisley, David S.—Director, A.M. Bisley & Co., Ltd., PO Box 487, Hamilton, New Zealand

Carrillo, Julian G.—Instruction director in agricultural machinery, Institute of Inter-American Affairs. (Mail) General Borgono 312, Miraflores, Lima, Peru, S. A.

Cornfoot, Douglas C. — On duty with USAF. (Mail) 95 Oakland Ave., Wollaston 70, Mass.

Dahl, Niels J. — Head, civil engineering dept., Royal Veterinary and Agricultural College, Bulowsvej 13, Copenhagen V, Denmark

Dolan, Martin W.—Field engineer, R. M. Wade & Co. (Mail) RR 1, The Dalles, Ore.

Duesler, W. C.—Sales manager, J. I. Case Co., Racine, Wis.

Duke, Welborn A.—Sales engineer, Russell Daniel Irrigation Co. (Mail) Claxton, Ga.

Edgerton, William R. — Chief engineer, Whitney Chain Co., PO Drawer 1410, Hartford 2, Conn.

Fell, Ferol—Student engineer, experimental engineering dept., John Deere Dubuque Tractor Works, Dubuque, Iowa

Fellows, John H.—Field engineer, Timken Roller Bearing Co. (Mail) 4444 W. Capitol Dr., Milwaukee, Wis.

Gardner, Bernard L.—Student in mechanical engineering, University of Maine, Orono, Me. (Mail) 2-C South Apts.

Glasscock, Jr., Earl P. — Agricultural engineer, agricultural development dept., South Carolina Electric and Gas Co. (Mail) Box 168, Denmark, S. C.

Glesmann, Herbert C. — Farm equipment retailer and partner, Glesmann Implement Co., Papillion, Nebr.

Haager, Paul L.—Assistant chief engineer, The Timken Roller Bearing Co., Canton 6, Ohio. (Mail) 124 Ironwood, S.W.

Hamilton, James R.—Associate professor in agricultural education, Mississippi State College, PO Box 1419, State College, Miss.

Hayden, Francis E. — Instructor, product education dept., Massey-Harris-Ferguson, Inc., Racine, Wis. (Mail) 601 Hayes Ave.

Hering, Carroll H. — Production trainee, Ralston Purina Co. (Mail) RR 2, Mart, Tex.

Jones, Robert, B. — Tire engineer, Firestone Tire and Rubber Co., Akron, Ohio. (Mail) 1077 Valdes St.

Judy, Dalton T.—Graduate student in agricultural engineering, Alabama Polytechnic Institute. (Mail) RR 1, Orangeburg, S.C.

Lattimore, Daniel G. — Farmer, RR 1, Lawndale, N.C.

Mansperger, Jr., Carl A. — On duty with USAF. (Mail) 1211 Dismuke, Houston, Tex.

Milne, Robert J.—Agricultural engineering fieldman, Ontario Dept. of Agriculture. (Mail) Western Ontario Agricultural School, Ridgetown, Ont., Canada

Nunnery, Sidney A.—Assistant agricultural engineer, Clemson Agricultural College, Clemson, S. C.

Ragland, Jr., Harry S. — Partner, Stuttgart Machine Works, 16th & Leslie St., Stuttgart, Ark.

Ramey, Albert A. — On duty with USAF. (Mail) 1680 Case St., Batesville, Ark.

Razzak, Jamil A.—Junior mechanical engineer trainee, John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) 515 Vermont St.

Reeves, P. J.—Director of sales, The Timken Roller Bearing Co., 1935 Dueber Ave., S.W., Canton 6, Ohio

Runkle, Dean E.—Engineer's assistant, Allis-Chalmers Mfg. Co. (Mail) 1401 Lincoln Way, La Porte, Ind.

Sammarco, Peter — Assistant advanced design engineer, advanced engineering dept., McCormick Works, International Harvester Co., 2919 S. Western Ave., Chicago, Ill.

Sayers, Leland D. — Power use advisor, Southwestern Electric Co-operative, Inc., Greenville, Ill.

Shoemaker, Edward M. — Irrigation sales supervisor, Olin Mathieson Chemical Corp., 1010 Rialto Bldg., 220 N. Fourth St., St. Louis, Mo.

Simpson, Howard W.—Consulting engineer, 730 Crescent Dr., Dearborn, Mich.

Van Orman, Donald L.—District manager, industrial div., Timken Roller Bearing Co. (Mail) 1609 Hennepin Ave., Minneapolis 3, Minn.

Verhake, Thomas L. — Agricultural representative, sales development div., Caterpillar Tractor Co. (Mail) 124 Behrends Court, Morton, Ill.

Weber, Kenneth R.—Project engineer, Allis-Chalmers Mfg. Co. (Mail) 3rd & Badger St., La Crosse, Wis.

Williams, O. G.—Assistant agricultural and food attache, British Embassy, 3100 Massachusetts Ave., N.W., Washington 8, D.C.

Transfer of Membership

Dillon, R. M.—Chief development engineer, Massey-Harris-Ferguson, Ltd. (Mail) 2045 Camilla Rd., RR 1, Cooksville, Ont., Canada. (Associate Member to Member)

Isaacs, G. W.—Assistant professor in agricultural engineering, Purdue University, Lafayette, Ind. (Associate Member to Member)

Kitching, H. W. — Farm machinery specialist, agriculture div., FAO, Room 712, Rome, Italy. (Affiliate to Member)

McDow, John J. — Head, agricultural engineering dept., Louisiana Polytechnic Institute, Ruston, La. (Associate Member to Member)

Miller, H. F.—Acting head, farm machinery section (AERB, ARS), USDA, Plant Industry Station, Beltsville, Md. (Associate Member to Member)

Schram, Jack R.—Supervisor, product training, sales training dept., Tractor & Implement Div., Ford Motor Co. (Mail) 1083 Oxford Rd., Berkley, Mich. (Associate Member to Member)

Schwiesow, W. F.—First assistant in agricultural engineering, University of Illinois, Urbana, Ill. (Mail) 1004 E. Florida Ave. (Associate Member to Member)

BURLAP BULLETIN

News about packaging and agricultural and industrial developments in burlap

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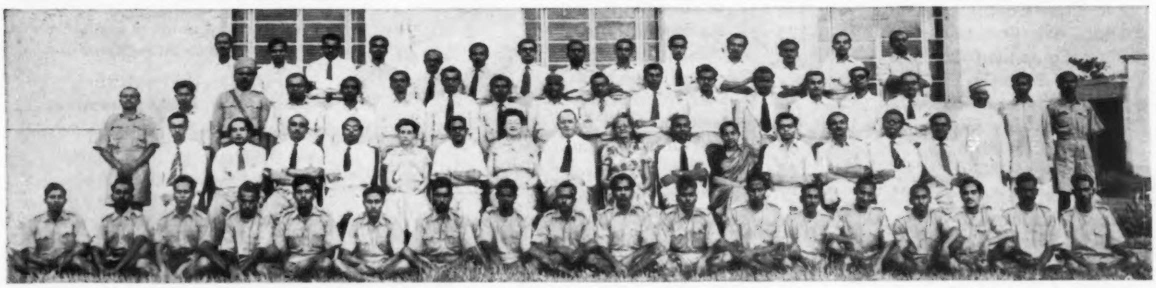
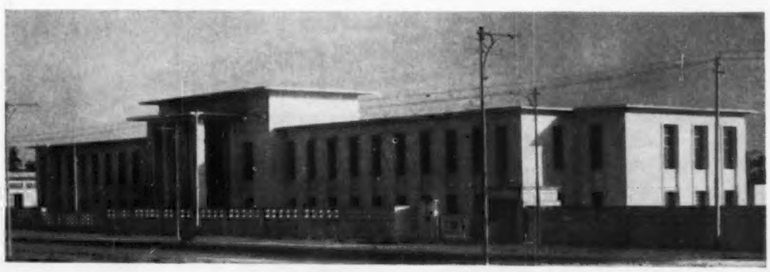


The Indian Jute Mills Association Research Institute (IJMARI) of Calcutta, India. Over 80 scientists, technologists and other workers devote their entire attention to the testing and development of jute and jute fabrics in six separate but related groups. These are Background Research, Applied Research, Development Research, Technical Service, Standardization, and Information Service. Among the many valuable contributions made by the Research Institute to the cause of improving jute products and their utility as packaging and industrial fabrics, are the development of a rot-proofing process and a method of bleaching and softening burlap; as well as the use of an asphalt-impregnated jute fabric in war-time construction projects which demonstrated a principle which may soon be successfully applied to important agricultural uses. The work of this staff has directly benefited American agriculture and industry through the advances in the quality and performance of burlap, and the adaptation of the fibre to new uses where it has effected a saving of time or money.

DR. W. H. MacMILLAN, Ph.D., B.Sc.— Research Director of the Institute who first came to Calcutta in 1937 as chief chemist of the Indian Jute Mills Association. He is the author of over 50 scientific and technical papers and plays an important part in the scientific and textile societies

of India. He is Chairman of the Calcutta section of the Textile Institute of Great Britain and Northern Ireland. His assistance is available for the solution of any problems submitted on behalf of American agricultural and industrial engineers.



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